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A COMPARISON OF THE EFFECTIVENESS OF SCIENCE EDUCATION IN KOREA AND SOUTH AFRICA:

A MULTILEVEL ANALYSIS OF TIMSS 2003 DATA

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Summary

Science education becomes more important for future national development globally in high-technology-based society. In reaction to the trend, the International Association for the Evaluation of Educational Achievement (IEA) has conducted achievement tests in science along with mathematics, called TIMSS every four years. In TIMSS 2003, while Korea was a higher-performing country, South Africa was ranked in the lower-performing countries. Korea features homogenous demography, centralized curriculum, and competitive educational zeal while South Africa is characterized by multicultural demography with various languages, and previously segregated schools based on races. The current research, which is a secondary analysis of TIMSS 2003 data, aimed at explaining the differences and similarities by identifying factors most likely to influence science achievement in the two countries.

A conceptual research framework was built on the comprehensive literature review which involved mainly school effectiveness research and factors related to science achievement. The conceptual framework consists of multi-levels, viz., student, classroom, school, and context, and three key concepts, namely time on task, opportunity to learn, and quality.

Two research questions were formulated to reach the goal of the research and the first question is: To what extent does TIMSS 2003 reflect factors related to effective science education? Data from the student, teacher and school questionnaires were included in conjunction with the achievement data and analysed by means of factor, reliability and correlation analyses. The factors found to influence science achievement in three levels are as follows: at the student level, books at home, attitudes towards science, time on task; at the classroom level, time scheduled for science and teacher interaction; at the school level, school size, community size, and student background.

The second research question is: To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students? To answer this question, the current research used multilevel modelling techniques to deconstruct the total variance in achievement into within- and between-classroom/school level. The strongest predictor is attitudes towards science in both countries at the student level. Student background in Korea and safety in school in South Africa is the strongest predictor of science achievement at the classroom/school level. Furthermore, educational resources such as books at home and educational level of father are significant in Korea while language, teacher qualification, physical resources, and educational leadership are significant in South Africa. For Korea, 93% of total variance in science achievement occurred at the student level while only 7% was attributable to the classroom/school level. For South Africa, 41% of the total variance was assigned at the student level and 59% at the class/school level.

From this comparative study, it was recommended that development of student-centred teaching practices to address negative attitudes to science in Korea be considered as opposed to basic issues such as improving teachers' subject knowledge, developing language skills, and fostering a culture of learning to improve science performance in South Africa.

Key words: ***science education, school effectiveness, South Africa, Korea, factor analysis, reliability analysis, correlation analysis, multilevel analysis, TIMSS***

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List of Acronyms

AIC – Akaike Information Criterion
ANC – African National Congress
C 2005 – Curriculum 2005
DBE– Department of Basic Education
DET – Department of Education and Training
DoE – Department of Education
FET – Further Education Training
FIMS – First International Mathematics Study
FISS – First International Science Study
FML – Full Maximum Likelihood
FRD – Foundation for Research Development
GDP – Gross Domestic Product
GET – General Education and Training
HE – Higher Education
HSRC – Human Sciences Research Council
IAEP – International Assessment of Educational Progress
ICT – Information-Communication Technology
IEA – International Association for the Evaluation of Educational Achievement
IGLS – Iterative Generalized Least Square
IIEP – International Institute for Educational Planning
IRT – Item Response Theory
ISC – International Study Centre
IT – Information and Technology
KICE – Korea Institute of Curriculum and Evaluation
KMO – Kaiser-Meyer-Olkin
MAR – Missing At Random
MCAR – Missing Completely At Random
MEHRD – Ministry of Education and Human Resources Development
MIP – Mathematics Improvement Program
ML – Maximum Likelihood
MLA – Monitoring Learning Achievement
MNAR – Missing Not At Random

MOS – Measure Of the Size

NAEP – Nation Assessment of Education Progress

NCS – National Curriculum Statement

NELS – National Education Longitudinal Study

NRC – National Research Coordinator

NSAECE – National Scholastic Achievement Examination for the College Entrance

OBE – Outcomes-Based Education

OECD – Organization for Economic Cooperation and Development

OTL – Opportunity to Learn

PIRLS – Progress in International Reading Literacy Study

PISA – Programme for International Student Assessment

PLS – Partial Least Squares

PPS – Probability-Proportional-to-Size

QCM – Quality Control Monitor

RML – Restricted Maximum Likelihood

RNCS – Revised National Curriculum Statement

SACMEQ – Southern and Eastern Africa Consortium for Monitoring Educational Quality

SD – Standard Deviation

SE – Standard Error

SER – School Effectiveness Research

SES – Socio-Economic Status

SIMS – Second International Mathematics Study

SISS – Second International Science Study

SPSS – Statistical Package for the Social Sciences

STS – Society, Technology and Science

TCMA – Test-Curriculum Matching Analysis

TER – Teacher Effectiveness Research

TIMSS – Trend in International Mathematics and Science Study

UNESCO – United Nations Educational, Scientific, and Cultural Organization

UNICEF – United Nations Children’s Fund

VIF – Variance Inflation Factor

CHAPTER 1

INTRODUCING THE STUDY

1.1 INTRODUCTION

> *Both logically and educationally, science is the perfecting of knowing, its last stage. …To the non-expert, however, this perfected form is a stumbling block* (Dewey, 1916, pp. 219-220).

Science education is an attempt to transform the “stumbling block” identified by Dewey (above), into a building block for the future, and has thus become an important part of education. The rapid development of science-based technologies has a major influence on everyday lives, necessitating the development of scientific literacy and skills to manage them at the individual level. At the national level, the modern workforce draws on scientific skills and knowledge, and so science-based technologies became an important ingredient of development and surviving global competition.

High-quality science education has been highlighted for economic success around the world and research has shown that scientific skills have a strong relationship with the level of economic growth (Pillay, 1992; Thulstrup, 1999; Schofer, Ramirez & Meyer, 2000; Baker, Goesling & LeTendre, 2002; Hanushek, Jamison, Jamison & Woessmann, 2008). Based on studies of mathematics and science performance tests conducted globally for the past 40 years, Hanushek et al. (2008) concluded that countries with higher test scores experience far higher growth rates even after compensating for economic factors like the security of its property rights and its openness to international trade.

For reasons mentioned above, some international comparative studies have tested achievement of science and of mathematics, and have explored the contextual factors underlying the achievement. As one of the most influential international studies, the International Association for the Evaluation of Educational Achievement (IEA) has conducted achievement tests in science and in mathematics since the 1960s, aiming to identify the factors likely to influence student learning, thereby informing policy to improve student achievement around the world. In the Trend in International Mathematics and Science Study (TIMSS), administered in 49 countries in 2003 under the auspices of the IEA, South Korea and South Africa were found to be at the opposite ends of the spectrum (Martin, Mullis, Gonzalez & Chrostowski, 2004). While South Korea is ranked amongst the higher-performing countries, as are other East Asian countries, South Africa is ranked in the lower-performing countries in both science and mathematics. The wide difference between South Korean and South African results in TIMSS 2003 motivated this research to find factors underlying the science achievements and contribute to debates on school effectiveness research (SER) and the broader educational community.

TIMSS provides overall contextual factors as well as a snapshot of performance (Atkin & Black, 1997; Grigorenko, 2007), but does not focus on the particular factors which may influence performance. If a country or education system is to develop interventions to improve its own quality of education, it would first need to ascertain the status quo, but this, although an important first round of analysis, does not provide information about what could be targeted as a focus of intervention. Therefore, an in-depth study should be undertaken to obtain more specific knowledge as a basis on which to develop and implement appropriate interventions.

Alternatively, provoked by the finding in the 1960s that schools do not make a difference in terms of student attainment (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld and York, 1966), SER has shown that many important factors are likely to influence student achievement directly and indirectly. SER has formulated theories and developed models designed to account for the effectiveness of schools, especially in developed countries in North America or Europe. As will be argued later, the models, developed to explore school effectiveness can be used to investigate effectiveness of science education as well.

The current research is concerned with effectiveness of science education in developing and emerging countries, and consequently a comparison of science achievement in South Korea, an Asian country, and South Africa, an African country, was conducted from the perspective of SER. SER was used as the basis for building the conceptual framework for the study. While it has focussed mainly on the core subjects such as language or mathematics to examine school effectiveness, the current research studied the effectiveness of science education in order to contribute to the body of knowledge. This research, aimed at exploring factors related to science, has led the researcher to examine science achievement and contextual information offered in TIMSS 2003.

In the following sections, educational contexts in South Korea (1.2) and South Africa (1.3) are explored against each country's historical background. Some distinguishable characteristics have been identified in the Asian and African educational systems, and the investigations into educational contexts are made in terms of these factors. Next, the problem statement (1.4), rationale (1.5) and aims (1.6) for the study are presented. Finally, the research questions are described (1.7), followed by the structure of the dissertation (1.8) and conclusion (1.9).

1.2 EDUCATION IN KOREA

The most noticeable feature in Korean education is the aspiration for higher education which results in intense competition. According to Kim (2009):

> Wild goose family is the term referred to as a “split-household transnational family” (Yeoh, Huang & Lam, 2005, p.308) in which mother and children are overseas for children's education while father stays in Korea, working and financially supporting their family, started being used in Korean society after mid 1990s. This term is derived from the symbolic meaning of the bird, wild goose. Wild goose is the gift given to a couple, wishing for eternal love at Korean traditional wedding and the bird has been recognized as a very devoted bird sacrificing oneself for children.

Korean parents’ concern about education results in preparedness to make sacrifices to ensure their children receive the best quality of education they can afford. This is not necessarily satisfied by the public educational system. As a result, some spend tens of thousands of dollars (USD) annually to send their children to *hagwon*, private educational institutes for after-school tutoring, in various subjects. A report by the Bank of Korea showed that Korean families spent 7.4% of their household budgets on education during the first half of 2009, compared to those in Britain (1.4 % in 2008), the United States of America (2.6 %), and Japan (2.2 %) (Jung, 2009).

1.2.1 EDUCATIONAL CONTEXTS IN KOREA

Korea is located in northeast Asia between China and Japan, and has been divided since 1948 into the Democratic People’s Republic of Korea and the Republic of Korea. Hereafter, the latter is referred to as ‘Korea’ for convenience as this study involved only South Korea. The population of Korea was estimated to be 47,870,000 as of 2005 (UNESCO, 2005). With rapid industrialization, the rural population has continued migrating into urban areas, which resulted in the urban population constituting 80.8% of the whole population as of 2005 (Gill & Kharas, 2007). The adult literacy rate is 98%, with 89% of students attending preschool (UNESCO, 2005). The primary to secondary transition rate is 99%, with public expenditure on education at 4.6% of the GDP, and the student-teacher ratio in secondary school at 25:1 (UNESCO, 2005).

The population of Korea is remarkably homogeneous in terms of both ethnic origin and language, as are other Asian countries. Characteristics of Asian education can be characterized by four factors, viz., *tradition, westernization, competition*, and *centralization* (Hsiun & Tuan, 2003). All of those characteristics hold true for Korean education without exception and are discussed below.

Educational tradition: Korea was one of the oldest countries in the world alongside China, dating back from as early 2,000 B.C, with the first formal historical record going back to the first century A.D. Likewise, the Korean educational system had a long tradition of formal education. Korea traditionally had three main cultural bases, viz., Confucianism, Buddhism and Taoism, introduced in the 4th century A.D. through China. Among them, Confucianism has strongly influenced education. The first public educational institution, the National Confucian Academy, was founded in 372 A.D. and the Confucian classics became the major curriculum (Kim, 2002). Confucianism, which originated from the philosophy of Confucius, a Chinese sage, is a social, educational, and political code of ethics. It was adopted as the official code for maintaining social and political order in the 14th century in Korea (Kim, 2002). Confucianism placed a strong emphasis on ruling a country by the most educated individuals and social harmony through the relationships of subordinations within a family, a society, and a country. Since the 10th century, the Korean government has used Confucian classic-based examinations to select men for the civil service.

Korean teachers have tended to have a high social status since Confucian-heritage cultures have respect for a higher-educated man and hierarchical relationships (McGinn, Snodgrass, Kim, Kim & Kim, 1980, p.66; Adams & Gottlieb, 1993, p.164; Leung, 2001). Such tenets as the relationships of subordinations could account for Korean students' passive and obedient relationships with teachers. The Confucianism honouring of highly-educated individuals remains dominant and seems to influence Koreans' strong upward mobility through education to date, although superficially the education system has been Westernized.

In the late 19th century, before modernization, various kinds of educational institutions existed across the country, namely *Seong-gyun-kwan*, a highest academy founded and financed by the government; *Sa-hak*, a private secondary academy in Seoul, the capital city of Korea; *Hyang-gyo*, a local private secondary academy, and *Seo-dang*, a private primary academy (Kim, 2002). In particular, the number of *Seo-won*, a local private academy founded by the Confucian literati, reached 300 across the country and formed academic sectarianism through the late 19th century (Kim, 2002).

Historically, public and private academies based on Confucianism and *Han-ja*, Chinese script, privileged a few noble elites since *Han-ja* was difficult to learn and the access to education limited. With the goal of mass enlightenment and literacy, *Han-gul*, the Korean alphabet, was invented in 1446 during the reign of King Se-Jong. *Han-gul* consisting of 24 characters, 10 vowels and 14 consonants, was consistently disseminated in the middle classes and among women who were alienated from noble- and male-oriented education. Through the colonization of Japan, the traditional educational system based on the Confucian classics was phased out and replaced by a western education system along with large-scale use of *Han-gul*. *Han-gul* is considered one of the easiest languages to learn phonetically and has contributed to the rapid growth of the literacy rate in Korea.

Westernization of education: Roman Catholics in the late 18th century and Protestantism in the late 19th century were introduced in Korean society and modernization associated with Westernization burgeoned. Protestant missionaries influenced education in particular, founding schools (Kim, 2002) with the introduction of the first modern school in Korea in the 1880s (Ihm, 1995). Thereafter, a modern school system was established by the government, only to be curtailed by Japanese colonization between 1905 and 1945. Education provided under Japanese rule was aimed at assimilating and keeping Koreans subordinate to the colonial power, also limiting their skill development. Higher education was largely inaccessible to Koreans as the language of instruction was Japanese (Sorensen, 1994). However, at the time of liberation in 1945, the overall illiteracy rate had reached up to 78 percent, in spite of the lack of secondary schools and teachers in secondary education (Sorensen, 1994). To overcome the Japanese influence, a radical revision of the basic educational structure and curricula was undertaken under the US military occupation (1945-1948), using an American system and democratic ideology as a model. Ostensibly, the focus of the revision was to provide an equal educational opportunity for all (Kim, 2002).

The Education Law, stipulating a 6-3-3-4 schooling system[1], was promulgated in 1949 and the development of a modern Korean education system began (Paik, 2001). However, the civil war which ravaged the country from 1950 to 1953 drained the scant resources, exacerbated the poor situation and thus had an influence on the effective introduction of this system.

Although Korea has had a long educational tradition, the educational system has found difficulty surviving, firstly under colonization and then under civil war. Since liberation, the American military government and aid for restoring the devastated country has influenced Korean education. McGinn et al. (1980, p.89) argued that American assistance in this period was biased towards the provision of material aid such as textbooks or building classrooms rather than on reform of curriculum or instillation of democratization. Nevertheless, the modern Korean educational system developed from a curious blend of Japanese and American origins, impacting policymakers and decision-makers in government, including that of education.

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[1] 6 years of primary education, 3 years of junior secondary education namely middle school, 3 years of senior secondary education namely high school, and 4 years of higher education namely university.

This legacy of Westernization, colonization and civil war in a comparatively short period resulted in the breaking down of traditions and Korean culture, and became a national cause for concern, in response to which the Charter of National Education was issued in 1968, becoming the philosophical basis underlying recent Korean educational development (Hong, 1983, p.209).

Competition: The most noticeable feature in Korean education is the aspiration for higher education which results in competition. Despite the Confucian heritage which emphasized scholarship and education, a strict class system in the past restricted education only to the upper class. The mixing of classes did not occur and as such the majority of commoners had no access to education. In addition, under colonization, discriminating and degrading educational policy did not satisfy expanding educational needs. Higher education was not offered to Koreans for similar reasons that it was denied to Blacks in South Africa. Japan tried to prevent Koreans from entering the upper classes, however the historical distinguishable boundary between the upper and the lower classes faded as the society was modernized and Westernized, and so anybody could pursue upgrading their social status. Consequently, education became the only gateway to upward mobility in the process of transformation from a highly stratified society to a system based on democracy and meritocracy, and as such the Korean aspiration for education, documented in the research, is reviewed below.

Human resource development followed a similar pattern to other countries with a much higher level of per capita GNP in 1965 (McGinn et al., 1980, p.62). In 1970, 87% of the population was already literate, although the government’s economical support of education was not high compared to international standards (Adams & Gottlieb, 1993, p.159). It is only since 1979 that fee-free primary education has become the norm, with partial free lower secondary education beginning from 1985 (Kim, 2002), even though the enrolment rate at primary level was already at 100% in 1970, with the lower secondary level reaching 100% in 1985 (Ihm, 1995). As seen in TIMSS 2003, 79% of Korean students tested expected to finish university compared to the international average of 54% (Martin, Mullis, Gonzalez & Chrostowski, 2004). Such an aspiration for higher education was commonly explained by Confucian-heritage cultures, as mentioned above (McGinn et al., 1980, p.66; Stevenson & Stigler, 1992; Adams & Gottlieb, 1993, p.164).

Along with such an upward mobility through education, examination-oriented educational systems have been driving Korean education into the level of being competitive to a greater extent in order to obtain entry into the prestigious schools, so-called ‘first-class schools’. The first state examination dates back to 788 A.D., when the government established Confucian classics-based examinations to qualify and to select individuals into government positions (Hwang, 2001). Comprehensive entrance exams for the lower secondary (middle) and the upper secondary (high) school was implemented from 1953 to select the best qualified under the limited secondary education available (Paik, 2001).

As a result, the highly competitive entrance examination system resulted in raising parents’ cost of private tutoring, students’ study stress, and teachers’ distorted implementation of the curriculum. As the government pursued equalization of quality of the lower and the upper secondary schools, as well as the relief of studying pressure on students, such competitive examinations for entry were phased out from the late 1960s at the lower secondary level through the upper secondary level. Instead, a more balanced implementation of the curriculum is emphasized across the country, yet the entrance examination to the higher education, formally called the National Scholastic Achievement Examination for the College Entrance (NSAECE), which corresponds to the matriculation examination of South Africa or the Scholastic Assessment Test (SAT) of America, remains and is reiterating past problems such as distortions of the curriculum and the burdensome cost of private tutoring.

Centralization: Korea has a centralized educational system, just as its government is highly-centralized. The Ministry of Education and Human Resources Development (MEHRD) is responsible for establishing policy regarding all education and scientific study, including formal and lifelong education and academic standards. MEHRD administers all universities and colleges directly, and all primary, lower and upper secondary schools fall under the responsibility of local boards of education administered by MEHRD (Robitaille, 1997). MEHRD, together with the Korea Institute of Curriculum and Evaluation (KICE), are responsible for developing the national curriculum at primary, and lower and higher secondary school levels.

The national curriculum is subject to periodic revisions under the auspices of MEHRD, with seven from 1954 to date (Organization for Economic Co-operation and Development {OECD}, 1998). Since the Sixth National Curriculum revision in 1992, curriculum decision-making has transferred slowly to local education authorities and schools, which have tried to diversify the curriculum to reflect students' needs (Ham, 2003). Despite the diversification of the intended curriculum, MEHRD still has control over the curriculum in public and private schools, in particular by screening published textbooks (Robitaille, 1997; OECD, 1998). In terms of curriculum and administration, at the primary and secondary levels, there is little difference between public and private schools other than their founders (Kim, 2002). Consequently, the school curriculum is uniform in all of the schools, with principals responsible for monitoring its implementation at the classroom level.

Aside from the four characteristics reviewed above, Korean *economic development* should be noted in relation to expansion of education. Even though Korea is considered a poorly resourced country, and has suffered the consequences of colonization and the war that severely devastated the land, it has made dramatic changes during the last 50 years that have taken centuries for most developed countries to effect (Ellinger & Beckham, 1997). The GDP, which was 155 dollars per capita in 1960 (McGinn et al., 1980), reached 22,000 dollars per capita as of 2005 (UNESCO, 2005), as Korea became the 11th largest trading country.

Korean economic growth since the 1960s is considered to have a bearing on education expansion (McGinn et al., 1980; Han, 1994; Ihm, 1995). The economic radical expansion needed highly-skilled workers and engineers as well as technology. In reaction to the rising demand, the government established vocational schools in 1963 and encouraged mathematics and science (Paik, 2001). In keeping with national financial support and industrial demand of trained manpower, scientific and technical education was given special and sustained attention, and vocational education, which trained technicians and mechanical engineers, flourished in the 1970s (Han, 1994; Sorensen, 1994). As an additional point, it should be noted that vocational education confronts challenges resulting from the worldwide shift of industry structure from manufacture to an IT-centred industry and the Korean preference of an academic education over engineering (Ihm, 1995). As a result, the education system, which began to supply a well-trained and qualified labour force, could support remarkable economic growth (Ellinger & Beckham, 1997).

1.2.2 THE SCHOOLING SYSTEM IN KOREA

The general schooling system in Korea includes the primary, the lower secondary (middle school), the upper secondary (high school), and higher education. Primary school covers Grades 1 to 6, the lower secondary school Grades 7 to 9, the upper secondary school Grades 10 to 12, and higher education from college or university to postgraduate courses. The upper secondary schools are divided into two main streams, such as academic and vocational schools. The latter are generally considered less preferable than the former, so higher-performing students tend to follow the academic track while those with lower scores follow the vocational one. Parents with high performing students prefer to send their children academic schools. In Grade 12, students approaching higher education take another round of examinations, the National Scholastic Achievement Examination for the College Entrance (NSAECE), which corresponds to the matriculation examination of South Africa.

After 1996, the duration of compulsory education increased from six years to nine years, that is, up to Grade 9. Specialized high schools in the 1990s were designated for science, foreign languages, the arts, Information and Technology (IT) and athletics (Kim, 2002). The academic year has two semesters, the first from March to August, the second from September to February. There is a summer and a winter break at the end of each semester and, in total, the school year usually consists of around 220 days (Diem, Levy & Vansickle, 1997).

1.2.3 THE SCIENCE CURRICULUM IN KOREA

At the time when the first curriculum was promulgated in 1955, science was so new for Korea that the vocabulary related to science hardly existed in the Korean language, and had to be invented before textbooks could be written (Sorensen, 1994). However, emphasis on science and mathematics has been prominent since the 3rd revision in 1973, in keeping with economic development (Shin & Huh, 1991). The Korean national curriculum has been revised periodically, with the seventh revision being implemented from 2000 (Ham, 2003).

Science education begins in Grades 1 and 2 in primary education as an integrated subject entitled “Intelligent Life”, with social study and practical arts. From Grades 3 to 10, science is taught as an integrated but independent subject. At Grades 11 and 12, science is divided into physics, chemistry, biology and earth science, which are chosen by students according to their needs. Therefore, no tracking or streaming is implemented until Grade 10.

Science education at the secondary level features a low percentage of practical activities and a high percentage of teacher-centred, conventional teaching strategies focusing on the academic content (Han, 1995). Even the practical work in the science class is shown to emphasize factual recall and illustrative activities based on a positivistic view rather than an inquiry-based investigation (Swain, Monk & Johnson, 1999). In an attempt to improve quality in the early 1970s, an inquiry teaching method was introduced from the USA, aimed at replacing the existing expository method of teaching. However, it did not take root in Korea because it did not fit the country's hierarchical relationship and large size class, 40-50 per classroom (Adams & Gottlieb, 1993). Under the ethos of examination-driven education, especially at the higher secondary level, emphasis is placed on simple and intellectual skill and training while little attention is paid to the development of higher-order thinking through practical work, such as experimental activities and field work in science classrooms.

In an attempt to make changes to such a legacy, the content in the science curriculum was reduced and emphasis placed on the mastering of basic skills to counteract the poor achievement in the Second International Science Study (SISS). One such change was the sixth curriculum revision of 1992, introduced in 1996. Coupled with the trends of constructivism, emphasis was also placed on higher thinking skills, problem solving in everyday life and the application of science to real-life problems (Han, 1995). The recent curriculum change has made a slight positive change from conventional science classes into constructivist-oriented ones, though this is still inadequate to address the needs (Kim, Fisher & Fraser, 1999).

On the other hand, since the 6th revision of the curriculum, science has been an integrated subject in Grade 10 and one of two optional subjects chosen from four areas by Grades 11 and 12 students in the higher secondary level. As a consequence, many science teachers were compelled to teach out-of-field and this has led to a decrease of teaching quality and student interest. It was reported that the science performance of Korean students suffered a decrease in ranking from 4th to 11th in the recent Programme for International Student Assessment

(PISA) administered in Grade 10. Although since the 6th revision emphasis has been placed on constructivist teaching in science, Korean science teachers still tend to rely on textbooks more than those in other countries (Martin, Mullis, Gonzalez & Chrostowski, 2004), preferring them to a variety of materials and strategies specified in the revised curriculum.

The implementation of the curriculum usually is supported through pre-service and in-service teacher education, textbooks, instructional or pedagogical guides, government notes or directives, and a system of school inspection or audits. A countrywide assessment of science is in place at Grades 4 to 8, 10 and 11 to monitor student achievement (Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden & O'Conner, 2000). Highly-centralized curriculum teaching relying on textbooks, which are strictly screened, does not differ across schools and the uniformity and limited curriculum resources were criticized as a problem (Shin & Huh, 1991). Although the 7th revision made an attempt to decentralize curriculum and offer more autonomy to each school, the curriculum implemented by teachers mainly based on textbooks is not yet varied enough at the school and classroom level (Ham, 2003).

Science teachers are trained at colleges or universities for four years, taking credits allocated in each area of general education, the programme of teacher education, and a specialty such as science. Primary school teachers and secondary school teachers receive their bachelor's degree and teaching certificates. Every year the local board of education administers the selection examination to newly recruited teachers, with the test covering subject-matter knowledge and the pedagogy related to the subject (Kim, 2002). There is a need to change the manner of selection of teachers to ensure that they are qualified to teach science effectively and so as to prepare students to develop higher-order thinking.

1.2.4 SCIENCE ACHIEVEMENT IN INTERNATIONAL STUDIES

Korea has participated in two international studies, including TIMSS and PISA to identify the strengths and weaknesses of the educational system, to develop appropriate policy, and to improve the educational system (Lee, Kim, Park, Cho, Si & Choi, 2005). In TIMSS 1995, Korea scored an average of 546 (SE 2.0), compared to the international average of 518. In this international achievement study, Korea was second in all the science content areas of earth science, life science, physics, chemistry and environmental issues and the nature of science. In TIMSS 1999, Korea scored an average of 549 (SE 2.6), against the international average of 521, while in TIMSS 2003 it scored 558 (SE 1.6) on average, compared to the international average of 474. Despite their high scores, Korean students have negative attitudes towards science. The apparent contradiction between Korean students' high scores in consecutive TIMSS administrations and negative attitudes towards science intrigues the researcher to investigate this discrepancy. The details of TIMSS are presented in the next chapter.

PISA is an internationally standardised assessment jointly developed by participating countries and administered to 15-year-olds in schools on a three-year cycle under the auspices of OECD (OECD, 2007). The first PISA survey was conducted in 2000 with 43 participating countries and focused on reading literacy. Korean students performed at 552 in PISA 2000, the international average being scored at 500. With the second cycle, PISA 2003 placed emphasis on mathematics literacy but reading literacy and scientific literacy was also assessed to a lesser degree in 41 countries. Korean students performed at an average of 538 in scientific literacy with the international average scored at 500. PISA 2006, conducted recently, focused on scientific literacy and took place in 57 countries. Korea performed at 522 in PISA 2006 compared to the OECD mean of 500. On the whole it was among the highest-performing countries (OECD, 2007).

The high performance of Asian students including Koreans in international comparative studies has been studied among researchers to explain and account for the phenomenon. One explanation is that the high value of education based on the Confucian heritage, together with a strong family structure and commitment to children's education, has contributed to such success in science and mathematics (Stevenson & Stigler, 1992; Kim & Chun, 1994; Peng & Wright, 1994; Sorensen, 1994; Ellinger & Beckham, 1997; Paik, 2001). In addition, it was documented that most Asian parents value schooling more than those in other countries (Stevenson, Lee & Stigler, 1986; Peng & Wright, 1994; Shen, 2005), and this may again be explained by the Confucian heritage as described above. Families consequently place pressure on students to get better scores as educational outcomes. Parents, in particular mothers, become involved in school work such as homework and push their children to attend after-school classes or private tutoring to supplement the academics, regardless of expense (Ellinger & Beckham, 1997). They push their children to spend more time studying and are willing to pay more money for extra tutoring (Sorensen, 1994; Hwang, 2001; Paik, 2001). It seems that such a zeal for education motivates students to study hard. It was documented that Korean students' science achievement within school level could be attributed mostly to student learning motivation, such as educational aspiration and confidence in science (Park & Park, 2006).

In the early stage of modern educational development, in the 1960s and early 1970s, Korea subsidized the costs of secondary and higher education much less than did other developing countries, due to the lower economic status and relatively high defence budget. However, parents' private support has contributed sufficiently to make up for the low public expenditure for education in Korea (McGinn et al., 1980). It was documented that the total proportion of GNP devoted to education by parents in South Korea reached up to 15 percent, excluding private tutoring (Sorenson, 1994). Parents are willing to send their children abroad for a better education, and in 2000 Korean students studying at American colleges and universities made up 8% of all international students studying in America and ranked fourth after those from China, Japan, and India. Given that educational success and socio-economic status in Korea correlate better than in other countries (Pillay, 1992; Sorensen, 1994; Lee & Brinton, 1996; Smits, Ultee & Lammers, 1998), it is understandable that the strong upward mobility and zeal for higher education has led to family commitment to education at any expense. At the national level, the long time students spent on study, the high standard of the curriculum, and the examination system were pointed out as contributing to such success (Stevenson et al., 1986; Peng & Wright, 1994; Ellinger & Beckham, 1997; Shen & Pedulla, 2000; Paik, 2001; Shen & Tam, 2008).

Significantly, Hwang (2001) argues that traditionally Korea had outstanding resources for students to learn mathematics and science, citing many examples such as *Han-gul*, invented in 1446 and considered one of the easiest scientific languages to learn, *Jikji*, confirmed by UNESCO as the world oldest metalloid printing frame, *Chum-sung-dae*, built in the 7th century and the oldest astronomical observatory in the East, and *Sok-ku-ram*[2], a Buddhist artificial-cave temple built in 951 and one of seven UNESCO institutions of world heritage. Furthermore, in the process of industrialization in the 1970s, special national and institutional emphasis was placed on science and mathematics in Korea (Sorensen, 1994; Hwang, 2001).

On the other hand, in contrast to their high performance, Korean students' self-confidence in learning science and valuing it are the second lowest, ahead only of Japan, and enjoying science is the worst amongst the participating countries (Martin, Mullis, Gonzalez & Chrostowski, 2004). Coupled with such negative attitudes towards science, aversion to science and engineering as majors in higher education and careers in society has caused serious concern at the educational and national levels. Consecutive IEA studies also showed vast

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[2] The sculpture of this cave temple is recognized as one of the finest achievements of Buddhist art in the East.

gender gaps[3] in science compared to mathematics, although the gap is diminishing.

1.3 EDUCATION IN SOUTH AFRICA

According to the African National Congress (ANC) Education Department (1995, p.6):

> *The journey we are embarking on is long and hard. The educational problems of our country run deep, and there are no easy or quick-fix solutions. But this framework maps a way toward the transformation and reconstruction of the education and training system and the opening of access to lifelong learning for all South Africans. We need to walk this path together in confidence and hope.*

Education was racially segregated during the long history of colonization followed by apartheid in South Africa. After the 1994 democratic elections, the new government envisaged to provide equal education to the entire population. After 12 years (1997-2009) of enormous educational frustration and the spending of millions of Rand, the minister for basic education announced plans to phase out Outcomes-Based Education (OBE), which was the guiding principle for a post-apartheid curriculum in South Africa at both the primary level and secondary levels (*timeslive.co.za*, 2000).

1.3.1 EDUCATIONAL CONTEXTS IN SOUTH AFRICA

South Africa is situated at the southernmost tip of the African continent, with a population that reached 47,939,000 in 2005 (UNESCO, 2005), of which 58.4% was urban by 2002 (World Bank, 2004). The adult literacy rate was 59.2% and 69.4% of youth were literate (UNESCO, 2005). The primary to secondary

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[3] Korean boys scored higher than Korean girls in science with the differences of 24 (3.6) in TIMSS 1995, 21 (5.1) in TIMSS 1999, and 12 (2.5) in TIMSS 2003.

transition rate was 90% in 2003 (UNESCO, 2005). Public expenditure was 5.3% of GDP and the student-teacher ratio in secondary school is 29:1 in 2007 (UNESCO, 2007).

South Africa is a multicultural society, in contrast to the homogeneous South Korea. The population in 2001 consists of 78.8% Blacks (“African”), 8.7% mixed race (“Coloured”), 2.5% of Asian origin (“Indian”), 10.2% Whites and 0.1% unspecified others. There are 11 official languages in South Africa: Afrikaans, English, IsiNdebele, IsiXhosa, IsiZulu, Sepedi, Sesotho, Setswana, SiSwati, Tshivenda, and Xitsonga (Webb, 2002).

Reflecting on such multicultural and complex aspects, Gray (1999, p.262) referred to South Africa as “a country with a peculiar mix of developed and developing world features, but essentially developing world in character”. The educational context of South Africa reviewed here focuses on Blacks as the majority of the population. South Africa, and indeed many other African countries, is characterized by a long experience of colonization (from 1652 to 1910, followed, by apartheid until 1994), and thereby *poor resources, reform endeavour*, and many *languages* in one country.

Poor resources: After colonization in 1652, the colonial powers provided schools for the children of settlers while education for Black children was introduced by missionaries. From these beginnings, education in South Africa remained segregated according to different racial groups, which has resulted in a backlog in education delivery and unequal distribution of resources (Mzamane & Berkowitz, 2002). Segregation and inequalities based on different racial groups, customs, and practice were enshrined in law from 1948. White schools were well funded by the government while African schools were poorly funded and had limited resources, and such imbalances in education resulting from apartheid were aggravated by the enactment of such laws as the Bantu Education Act of 1953 (Fiske & Ladd, 2004).

Disparate financing by the White governments resulted in poorly resourced African schools, under-qualified teachers and a high drop-out rate of Black students. The curriculum of Black schools consisted of manual work-related and simple skill-centred subjects so that it met the government’s economic and political demand for workers or labourers who were expected to serve White-centred industry and community. The total education expenditure for African education in 1988 was less than half of that for White education, although enrolment of Black learners was 7.5 times as high as White enrolment (Seroto, 2004).

Additionally, Black teachers were trained in two-year colleges until 1983. These colleges had poor academic standards, resulting in inadequately qualified teachers, unable to deliver effective teaching (Seroto, 2004). Such insufficient support of African education led to a wide gap in matriculation results between White and Black learners. For instance, in 1989 when different education systems and different exams still existed, the Black matriculation pass rate was 41.8%, whereas 96.0% of White learners passed the matriculation examination[4], including the percentage of exemption from the exams respectively. Such a wide gap between White and Black learners was often attributed to the Soweto uprisings in 1976, in that it embedded in Black students a culture of resistance against education, rather than promoting a desire for education (Glover, 1992).

Reform endeavour: After the 1994 democratic elections, in order to overcome the marked backlogs and inequalities, the South African government undertook many initiatives, for instance the revision of the curriculum, and attempted to redistribute funding based on socio-economic circumstances of schools (DoE, 1999). The country of South Africa, which had previously been defined as African homelands and White provinces (which included urban non-White areas), was reorganized into nine administrative provinces. Accordingly, the previous educational departments based on racial groups and locations were redefined

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[4] The external national final examinations written at the end of Grade 12

into nine provincial departments of education, regardless of race. The first post-apartheid government enacted a series of legislative acts such as the White Paper (1995), the National Education Policy Act (1996), the South African Schools Act (1996), and the South African Qualifications Authority Act (1995). In addition, new National Norms and Standards for School Funding were uniformly promulgated in 1999 across the nine provinces. The norms and standards were intended to realize equity in the distribution of resources by progressively redistributing non-personnel expenditures in schools (Mzamane & Berkowitz, 2002).

In addition, curriculum reforms were introduced to redress deficiencies from the inadequate policies of the past government. Outcomes-Based Education (OBE) was introduced in the form of Curriculum 2005 (C2005) to replace the old apartheid curriculum. C2005 was implemented in Grade 1 in 1998 and was gradually to be extended to the consecutive grades. According to C2005, the traditional content-based subjects were reorganized into eight learning areas to facilitate the process of learning and consisted of: Communication, Literacy and Language Learning, Numeracy and Mathematics, Human and Social Sciences, Natural Sciences, Arts and Culture, Economic and Management Sciences, Life Orientation, and Technology. Content was not prescribed by the curriculum, but it was expected that teachers would introduce relevant content to achieve the learning outcomes.

However, many critics argued that rather than C2005 being the solution to redress the past imbalances it brought with it many new problems. Firstly, the curriculum was implemented without adequate consultation with the teachers or with little consideration of the South African context (Jansen, 1998; Rogan, 2004; Vambe, 2005). Furthermore, the critics argued that OBE would have been more functional in well-resourced schools in developed and Western countries (Jansen, 1998). C2005 was thus seen as more beneficial to well-resourced urban White schools than the previously disadvantaged schools and, as a result, the inequalities intensified. Teachers expected to implement the new curriculum were under-qualified and inadequately trained, and consequently confusion arose among them and the students. Responding to the criticism, the curriculum was reviewed in 2001 by a Ministerial Review Committee and the Revised National Curriculum Statement (RNCS) was introduced for grades R-9 (DoE, 2001). For grades 10-12, the curriculum revision was named the National Curriculum Statement (NCS), and was implemented in 2006. Although the focus on outcomes rather than content was retained in the RNCS and NCS, some content was reintroduced in terms of Assessment Standards. Despite all these endeavours, a new curriculum reforms as of 2010 has once again been announced in an attempt to clarify content (DBE, 2010).

Language: Language is an issue in South Africa, particularly with its large number of languages and dialects. For Black students the mother tongue is the medium of instruction up to Grade 2 in school. Missionary schools for African learners used English as the medium of instruction in the early years of colonization, but from 1910 gradually increased the use of African languages in the initial school years. With the Nationalist party coming into power in 1948, schools and students were separated definitively according to race and mother tongue. Under the apartheid system, South Africa had two official languages, English and Afrikaans, which were used as the languages of commerce, science and higher learning. African learners preferred mainly to being taught in English due to better job opportunities. Nonetheless, unreasonable and inconsistent language policies finally led to the Soweto uprising in 1976 (Institute for Justice and Reconciliation, 2004). In July 1997, a new language policy was released and the option for the language of instruction became available according to the preference of parents and students.

Language policy in South Africa tends to be inextricably linked to political issues and has been the subject of intense debate (Mzamane & Berkowitz, 2002). From 1994, schools have undergone a drastic change in terms of demography, since

Black, Coloured, and Asian students may now enter the former White schools from which they were previously barred by apartheid policies. However, an important concern emerges in such mixing of demographics in school as these students can speak many languages but not even one language fluently (Seroto, 2004). This results in there rarely being a single language of instruction which all learners in a class understand, with a consequent impact on achievement.

1.3.2 THE SCHOOLING SYSTEM IN SOUTH AFRICA

After 1994, South African formal education was categorised into three levels, viz., General Education and Training (GET), Further Education Training (FET), and Higher Education (HE). GET covers preschool to Grade 9 and FET from Grade 10 to 12 in school, out-of-school youth and adult learners. HE consists of universities and universities of technology (previously known as *technikons*), and covers national diplomas, certificates and degrees. Grade 7 is the last year of the primary school setting while Grades 8 and 9 are offered in secondary schools. At the FET level, Grades 10-12 are offered in secondary schools and vocational and technical tracks, lasting from two to four years, are offered in FET colleges. Compulsory basic education is provided to Grade 9 (Mzamane & Berkowitz, 2002).

1.3.3 THE SCIENCE CURRICULUM IN SOUTH AFRICA

Under apartheid, a strong emphasis was placed on the development of human resources with a science orientation in order to support the economic base of South Africa, particularly for the minority White population (Naidoo & Lewin, 1998). In contrast, teachers in most Black schools were not trained and qualified to teach subjects such as physical science and biology, nor were the schools equipped due to the lack of necessary facilities such as science laboratory and science equipment. In addition, more emphasis was placed on the cultivation of unskilled workers to support the White-centred economic system.

General Science was taught in primary school and in the first two years of secondary school starting in Grade 8. General Science, a combination of Biology and Physical Science, was a compulsory subject for all students. From Grade 10, students could choose the separate subjects of Biology and Physical Science, which is a combination of Chemistry and Physics. The science subjects offered from Grades 10-12 were streamed into three levels of difficulty: lower, standard, or higher (Naidoo & Lewin, 1998). However, few Black students took courses in science and mathematics, as documented, with only 15 percent of all Black students in Standard 10 (corresponding to Grade 12) taking Physical Science in 1988 (Bondesio & Berkhout, 1995).

In keeping with Curriculum 2005, based on OBE and initiated by the new democratic government, Natural Science, one of the eight learning areas, had to make drastic changes from a traditional, teacher- and content-centred approach to a progressive, student- and outcomes-centred approach with the new curriculum and policy documents in South Africa tending to have been influenced by practice in Australia and New Zealand (Gray, 1999). The White Paper on Education emphasizes the importance of appropriate mathematics, science, and technology to make up for the chronic national deficit in these fields of learning and to improve scientific and technological education (Nieuwenhuis, 1996). From primary school up to Grade 9 in junior secondary school, Natural Science, including physical science, biology and earth science, is taught as a compulsory learning area. From Grade 10, it is separated into two subjects, which are called Physical Science and Life Science, which students may choose as optional subjects (Howie, 1999).

Curriculum 2005 requires teachers to plan and implement the curriculum to gain the intended outcomes from students (Killen, 2002). Nonetheless, many science teachers had not heard of nor were they familiar with the Curriculum 2005-related reports, such as Technical Reports for the Natural Sciences, in spite of great public dissemination (Jita, 1998). If, however, science teachers were familiar with them, they tended to focus on minor issues such as group work rather than on accomplishing the specific outcomes, indicating that they understood the intended curriculum in superficial and even trivial ways (Rogan, 2004; Rogan & Aldous, 2005). Under the ethos of matriculation-driven education to achieve high pass rates in the examination, the interactions between teacher and students are still low in the science classroom (Rogan & Aldous, 2005). Physical facilities for science classes are inadequate and, if available, practical work is not common, which indicates that intervention strategies should be considered as well as improving resources (Naidoo & Lewin, 1998; Hattingh, Aldous & Rogan, 2007).

Historically, the teacher education system was stratified racially and Black teachers were trained at segregated institutions designed only for Blacks, while the Department of Education and Training (DET) provided education to Black learners. Black teachers were trained in two year colleges, biased towards the humanities and arts subjects rather than mathematics, science and technology. As a result, most of the graduates from Black teacher training colleges were trained in religious studies and history, and science teachers as well as mathematics teachers were under-qualified (Sayed, 2002). The poorly qualified teachers in turn produced poorly performing students, repeating a vicious cycle of mediocrity (Howie, 1999). It was reported that in the DET in 1990 only 28% of mathematics teachers and 44% of physical science teachers were qualified in their subjects (FRD, 1993). It was only in 1983 that a three-year diploma was introduced at Black teacher training colleges (Seroto, 2004), giving an additional year to the two-year diploma in place.

At the turn of the millennium, some teacher training colleges were closed and others merged with universities. Now, teachers are trained at universities completing a 4-year education degree or a 3-year degree followed by a 1-year teacher’s certificate. To become a secondary school teacher one should specialize in two secondary subjects and teachers who teach physical science tend to also teach another subject, such as biology or mathematics (Naidoo & Lewin, 1998).

1.3.4 SCIENCE ACHIEVEMENT IN INTERNATIONAL STUDIES

South Africa has participated in international comparative studies, including Monitoring Learning Achievement (MLA), the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) project, and the three TIMSS administrations. Whereas TIMSS involves countries around the world, and evaluates mathematics and science for the junior secondary level (Grade 8), the SACMEQ project, limited to Southern and Eastern African countries, tests the Reading and Mathematics achievement levels at Grade 6, and MLA concerns Literacy tasks, Numeracy tasks, and Life Skills tasks at the primary level. The SACMEQ project, aimed at improvements in the quality of the conditions of schooling and student achievement levels, was conducted under the auspices of the International Institute for Educational Planning (IIEP) for over ten years. However, South Africa only participated in SACMEQ II, which commenced in mid-1998 (Moloi & Strauss, 2005). A closer look was taken in this research at TIMSS and MLA, since the two international studies involve science.

Following the World Declaration on Education for All, MLA was initiated in 1992 under the auspices of UNESCO in collaboration with UNICEF, aimed at enforcement of national capacities to monitor the basic educational programmes in general, and learning achievement in particular (Chinapah, 2003). The MLA project measures the learning attainment of students in literacy, numeracy and life skills/science to examine basic learning competencies as the minimum basic knowledge and analytical skills expected at the Grade 4 level (Chinapah, H’ddigui, Kanjee, Falayajo, Fomba, Hamissou, Rafalimanana & Byomugisha, 2000). In life skills, which included science in the MLA survey carried out in 1999, South Africa attained 47.1 (% mean score), well below the counterparts of other countries (HSRC, 2000).

In other international studies such as TIMSS, the results of South Africa were not very different from the study mentioned above. In TIMSS 1995, South Africa scored an average of 263 (SE 11.1), in TIMSS 1999 it scored 243 (SE 7.8) on average, and in TIMSS 2003 it scored 244 (SE 6.7) on average. Such a low performance was seen in other African countries, such as Ghana and Botswana, but the South African result was the worst. Despite the vigorous endeavour of the new government, South African students were ranked among the lowest-performing countries in all three administrations of TIMSS.

Some explanations for this poor performance of African countries, including South Africa, can be offered. Problems such as under-qualified teachers, poor resources, and language are prevalent in African countries (Glover, 1992; de Feiter, Vonk & van den Akker, 1995). South African results in TIMSS were shown to have a high correlation with English language proficiency for science (Howie, Scherman & Venter, 2008) as well as mathematics (Howie, 2002). For the majority of the population, African learners whose mother tongue is not English or Afrikaans, the language of learning in South Africa, could be a further obstacle to reduce school effectiveness since instruction is implemented in a second language (Howie & Plomp, 2003). Evidence illustrates that students with a lack of proficiency in English gave mostly incorrect answers in TIMSS (Dempster, 2006). Considering that many concepts or phenomena involve concepts in science that are counter-intuitive, complex, and often abstract in nature, it seems that poor language ability renders scientific understanding more difficult (Brophy & Good, 1986; Inglis, 1993; Gray, 1999). Gray (1999) argues that the language of science instruction is the single most significant obstacle to conceptual understanding in science that learners in the developing world face. Yet South African learners' poor performance in science cannot be completely accounted for by language problems (Dempster & Reddy, 2007).

The poor achievement in developing countries have often been attributed to poor resources such as school infrastructure and teacher quality, and this holds especially true for South Africa (Reddy, 2005a) as the legacy of the Apartheid system has resulted in an inequality of resources which tends to be more serious than in other countries. There are apparent achievement differences between advantaged schools and disadvantaged schools (Reddy, 2006), and this is the case particularly in rural areas where many schools still suffer from the lack of basic necessities such as water, electricity, sanitation, and even school buildings (Perry, 1997).

In addition, the issue of under-qualified teachers, trained in the former Black teacher training colleges, has been pointed out as one of the underpinning factors that produce weak and under-prepared learners for higher education and, in turn, lower achievement (Naidoo & Lewin, 1998). TIMSS 2003 shows that just 53% of South African students tested at Grade 8 were taught science by certified teachers as opposed to the international average of 87% (Martin, Mullis, Gonzalez & Chrostowski, 2004). Furthermore, many science teachers are deployed in other subjects as well as science. Given that teaching science requires more professional knowledge about the subject, these reasons make it difficult for the teacher to devote time to effective teaching practice (Jita, 1998). Such under-qualified and poorly prepared teachers in turn produce poor achievement in their students, resulting in a cycle of mediocrity (Howie, 1999).

Aggravating the situation, poor infrastructure and negative ethos prompt teachers to leave the teaching profession to find better occupations (Jita, 1998). As can be seen in TIMSS 2003, the percentage (75%) of science teachers under the age of 39 teaching Grade 8 in South Africa is higher than the international average (50%) (Martin, Mullis, Gonzalez & Chrostowski, 2004). Many teachers leave school in their early career, which results in fewer experienced and older teachers than other countries. Taking into account that teaching experience is one of the factors related to teacher effectiveness, the loss of teachers in their early careers could contribute to South African students’ poor performance in TIMSS.

The poor science performance in African countries, including South Africa, has been most commonly attributable to the cultural gap between Africa and Europe from which the science curriculum was adopted (Glover, 1992; Ogunniyi, 1993; Putsoa, 1993; de Feiter et al., 1995). The cultural gap resulted in a curriculum irrelevant to local contexts, with Western-based curricula demanding reasoning and objective thinking patterns as opposed to the African culture of narrative and anthropomorphic worldview. The lack of a learning culture, which includes a lack of enthusiasm for schooling, which was rooted in the political struggle against the previous apartheid regime, is also highlighted as contributing to poor achievement in science (Glover, 1992; Medupe & Kaunda, 1997; Howie, 1999; Medupe, 1999). Dzama and Osborne (1999) also documented that the absence of a supportive environment for serious science learning, where science features significantly in the popular culture rather than conflict or a gap between science and African traditional values and beliefs, is a more suitable explanation.

Interestingly, South African students did display positive attitudes towards science and felt that they had performed well in science, which is contrary to their results in TIMSS (Martin, Mullis, Gonzalez & Chrostowski, 2004).

1.4 PROBLEM STATEMENT

An examination of the ranking-table of TIMSS 2003 reveals that Asian countries performed well as a whole, in contrast to the developing world, which performed poorly (see Appendix A). Korean 8th grade students are ranked third in science and second in mathematics amongst 49 countries (Martin, Mullis, Gonzalez & Chrostowski, 2004), while South Africans performed the worst in both subjects. African countries have been struggling with poor performance in science, which is considered to be fundamental to development from dependence and poverty, and South Africa is no exception.

Since international organizations such as UNESCO and UNICEF stipulate education as a human right and initiated the Education for All movement two decades ago, access to basic education has been expanded to promote learning and life skills for more people. Nonetheless, many countries are grappling with ensuring the quality of education. This is more often the case in developing countries. When narrowing the scope on the quality of outcomes in educational systems, achievement can be taken as an interpretation of effectiveness in terms of quality and defined as subject-specific tests, such as in mathematics or science (Scheerens & Bosker, 1997). From the perspective aforementioned, the differences between Korean and South African achievements can be investigated to see how well each system functions for their students to reach goals proposed.

As presented above (1.2.1), Korea has a long history, which education reflects in many respects. Confucian belief systems which value well-educated individuals were adopted to maintain the government and based the fundamental curriculum on educating a new generation to follow it. Korean people have much zeal for higher education, which can be considered a gateway to upward mobility and higher social status. This is likely to contribute to high performance in international comparative studies. The aspiration of education leads to a competitive educational context and is criticized as it places high pressure on students to study hard to achieve well in examinations, thus distorting the implementation of the intended curriculum.

In contrast, South Africa experienced a long period of colonization linked to segregation which was later promulgated by the Apartheid regime. As a result, the African people were defiant which caused resistance to education as a method of segregation. This segregation had a devastating effect on African (Black) education in terms of equity. Africans (Blacks) were deprived of access to high-qualified schools due to discriminatory education policies by the Western colonisers, and were forced to receive an education for agricultural, mining, and domestic service. Such a system was regarded as invasive and South Africans developed a negative ethos about schooling which manifested itself in both students and teachers. Considering the above, it is not surprising that South African students have fared poorly in international comparative studies.

As evident from the examination of educational contexts in both Korea and South Africa, the comparison provides a great contrast. South Africa started formal education with the immigration of Western people, while Korea has a long educational history. Since modernization, Korea was mainly influenced by America whilst South Africa by European countries, mainly the Netherlands and England. Although both two countries experienced colonization, this historical background influenced the two countries differently with respect to education.

On the other hand, this wide gap between the two countries needs to establish a theory to explain the background especially in terms of school effectiveness research. Ever since the 1960s, school effectiveness researchers have studied the variation in student achievement in educational systems or schools based on educational indicators. Researchers found important factors which affect student achievement directly and indirectly, and formulated theories and models to be able to account for the effectiveness of schools (Teddlie & Stringfield, 1993; Creemers, 1994; Scheerens & Bosker, 1997; Teddlie & Reynolds, 2000; Howie, 2002).

Besides, for the most part, SER was involved in mathematics or language achievement to examine school effectiveness. However, there is an opportunity to examine school effectiveness in terms of other subjects, especially science, which is a priority subject in both Korea and South Africa. The vast differences in science achievement shown in the results of TIMSS can therefore be explored in the light of school effectiveness models more broadly by specifically incorporating factors associated with science achievement. Furthermore, SER has been criticized in the past as the quality of the data used is questionable. However, with TIMSS the quality of the data is excellent and thus a vehicle to explore SER factors.

1.5 RATIONALE FOR THE STUDY

UNICEF (2000) defines quality education by five dimensions: learners, learning environments, learning content, learning processes, and learning outcomes. Although the five dimensions should be examined comprehensively to assess educational quality, policymakers rely mainly on outcomes that demonstrate the extent to which the education system provides adequate education. Therefore, research in education tends to ascertain factors likely to influence learning outcomes.

Korean students are ranked third in science amongst 49 countries, while South Africans performed the worst in the subject in TIMSS 2003 (Martin, Mullis, Gonzalez & Chrostowski, 2004). While Koreans' high performance could be ascribed mainly to hard-work and educational zeal, a further result of TIMSS 2003, Korean students' negative attitudes towards science, demands some explanation and intervention. For South Africa, the TIMMS result was particularly disappointing, because ambitious educational projects have been initiated by government to improve education in an attempt to redress past inequalities brought about by Apartheid (Botha, 2002).

Variations shown across participating countries had led to investigating why the countries performed differently. Thus, the different educational contexts in Korea and South Africa are worth examining to explain the wide gap between the two countries in terms of science performance. The researcher, a secondary science teacher in Korea, undertook the study at a South African university, examining the wide differences between Korea and South Africa in terms of the TIMSS 2003 results, the education systems of the two countries as well as ethnographic aspects discussed above. This interested the researcher and provided motivation to explore the factors that could account for the differences in science performance.

Science as a subject is vital for the economic development of a country and international studies such as TIMSS are critical in giving countries an idea of student achievement in science and mathematics. However, there seems to be a dearth of knowledge in terms of secondary analyses of science performance using such international comparative datasets. By means of undertaking a secondary analysis of the TIMSS 2003 data, science teachers, school principals, and policymakers will be assisted in identifying key factors which focus on the development of an environment for more effective science teaching and learning in the two countries. The insight gained into the science educational practices of both countries, and the recommendations suggested and interventions put forward, could assist in improving attitudes or achievement, particularly in less resourced environments.

The research is meaningful for Korea, to gain additional insights outside of America, given that the greatest influence on the education system and science education has come from America thus far. South Africa is perhaps in a similar situation to Korea in the sense that Western science is not indigenous to the two countries, and so they may benefit from the Korean experience.

With respect to international comparative studies, the current research will be the first attempt to compare an African country with an Asian country using the TIMSS data. Secondary analyses thus far in comparing the results of TIMSS across the countries, have focused on the differences or similarities between European countries (Bos & Kuiper, 1999), between Asian countries (Leung, 2002), between the USA and Asian countries (Shen, 2005; House, 2006), or between European, Asian and American countries (Papanastasiou, 2002; Ramirez, 2004; O'Dwyer, 2005). The current study, comparing an African and Asian country, could suggest a more general view to comparisons across continents. Identification of factors that are common to the two countries and factors that operate in a different or specific way in each country could contribute to building both generic and differentiated models of effective science education, which are not available in the literature.

From the perspective of educational effectiveness, the research could be conducive to the generalizability of educational effectiveness models employing micro- and macro-levels at the same time (Reynolds, Creemers, Stringfield, Teddlie & Schaffer, 2002; Kyriakides & Charalambous, 2005). The research could thus contribute to enhancing consistency and validity of an educational effectiveness model used as a framework, because the study examined factors associated with effectiveness in science as opposed to mainly measuring reading ability or mathematics achievement as in previous research (Scheerens & Bosker, 1997; Kyriakides, 2005). In addition, making use of multilevel analyses offers a contribution to capacity building of education effectiveness research, and a further contribution is the testing of the utility and capacity of the use of TIMSS data for evaluation of educational effectiveness.

1.6 AIMS OF THE STUDY

The purpose of this research was to explore the variance between Korean and South African student achievement in science from the perspective of educational effectiveness. In order to accomplish such an aim, the current study focused on science achievement of Korean and South African Grade 8 students in TIMSS 2003, and explored the difference by means of secondary analyses of the TIMSS data. The aim can be translated as follows:

- To describe at each educational level, the factors which influence the achievement in science as taken from the student, science teacher, and school questionnaires of TIMSS 2003.
- To identify factors influencing achievement that are the same for both countries.
- To identify factors influencing achievement that are different for both countries.

- To provide explanations for the variation in science achievement based on the common and different factors in the two countries.

Ultimately, the identification of effective factors at each level can lead to appropriate intervention and improvement in terms of science education in the two countries. Comparing these two countries, that are remarkably different in terms of operation and goals of educational systems, could help generalization of the effectiveness of science education (Kyriakides & Charalambous, 2005).

1.7 RESEARCH QUESTIONS

In the light of the discussion in previous sections, it would appear as if further exploration into the variation of achievement is called for. This would provide additional information into the interpreting of the TIMSS results as well as providing a starting point for intervention strategies where needed. Based on the discussion, two main research questions can be identified:

Question I: To what extent does TIMSS 2003 reflect factors related to effective science education?

In order for this question to be answered, a theoretical framework was introduced for the research, and modified to reflect science-specific factors. During the past decade, effort has been made to develop effective science education (Millar & Osborne, 1998; Martin & Osborne, 2000; Tytler, Waldrip & Griffiths, 2004; Aikenhead, 2006) and as a result of SER, many effective factors specific to science have been identified. Such previous findings are fundamental to the development of the conceptual framework for this study. The TIMSS data were examined in terms of the framework. Since TIMSS collected background data by student, teacher/classroom, school, and context level, such multilevel data has enabled researchers to comprehensively examine the effectiveness of science education, which explains factors influencing students' achievement according to each level. For the study to reflect on such multiple influences on student achievement, the research question above can be translated into three sub-questions as follows:

1. Which factors at school level influence science achievement?
2. Which factors at classroom level influence science achievement?
3. Which factors at student level influence science achievement?

The above sub-questions helped the research identify and categorize factors from the data in various levels. Considering that the aim of the study is to eventually account for the variances between Korea and South Africa, another research question arises as follows:

Question II: To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?

The model, which includes factors identified as part of the first main research question, was used for both Korea and South Africa. In order to address the second main research question adequately, four sub-questions can be identified:

1. Which factors influencing achievement are generic when comparing Korea and South Africa?
2. Which factors influencing achievement are specific to Korea?
3. Which factors influencing achievement are specific to South Africa?
4. How do these generic and specific factors explain the difference in the performance of the two countries?

Answering the questions was accomplished by comparing the results of the multilevel analyses of the TIMSS data. Consequently, the procedure was to explore effectiveness of science education in Korea and South Africa by identifying factors influencing science achievement. Furthermore, identification of unique factors may motivate teachers to focus on the specific contextual factors.

In light of school effectiveness, previous research has suggested that in developing countries like African countries, school-related factors are more likely to influence student achievement as opposed to student-related factors in developed countries. Such a finding has not been confirmed in Asian countries like Korea thus far. Ultimately, the answers of the research questions helped to understand the variance of achievement in science in the two countries.

1.8 STRUCTURE OF THE DISSERTATION

The dissertation consists of nine chapters. Chapter 2 goes on to explore TIMSS looking back at the precedents of TIMSS, First International Science Study (FISS) and SISS. In particular, the framework, instruments, and contribution to research are explored. Chapter 3 includes a literature review, divided into SER and factors influencing science achievement. SER identified many factors likely to influence student outcomes and thus related to school improvement research and teacher effectiveness. In particular, SER is discussed in terms of developing countries and science subject. With respect to science, the factors influencing science achievement are reviewed according to student, classroom, and school levels. Based on reviews in Chapter 3, a conceptual framework for the study was built in Chapter 4, adopting the previous models concerning school effectiveness. The conceptual model built in this chapter consults mainly the Creemers' model referring to the Scheerens' model and the Shavelson, McDonnell, and Oakes model. Research design and methodology are described in Chapter 5. Issues such as post-positivism, and secondary analysis are discussed in Chapter 5. Thereafter instruments including science assessment and contextual questionnaires, methodological norms such as validity and reliability issues are elaborated on.

Data analyses, including factor, reliability, and correlation analyses are followed by multilevel analyses. The chapter concludes with ethical considerations taken into account when conducting this research. Chapter 6 presents descriptive analyses. The chapter focused on the description rather than explanation in order to show how Korea and South Africa are different in terms of science achievement and contextual information offered in TIMSS. In keeping with the first main research question the results of factor, reliability, correlation analyses were presented in Chapter 7. Taking all the results found, selection of variables for further analyses are carried out in closing the chapter. The second main research question was addressed with the results of multilevel analysis in Chapter 8. The variances explained at various levels in Korea and South Africa are presented in this chapter comparing the differences between the two countries. In Chapter 9, the final chapter of the dissertation, the results are summarized corresponding to the research questions. Thereafter discussion and reflections are made in terms of the conceptual framework, SER, and methodology used. Contributions to scientific knowledge follow it. Finally, the chapter offers conclusions and recommendations.

1.9 CONCLUSION

Chapter 1 introduced the study discussing educational contexts in Korea and South Africa. The educational contexts were explored in terms of history, schooling systems, science curriculum, and science achievement. The problem statement and rationale for the study are presented along with the research aims and questions.

Korea is remarkably homogeneous in terms of population, ethnicity, and language. Korean education was traditionally based on Confucianism, which emphasizes the most educated individuals, governance by them, and social harmony through the relationships of subordinations. Therefore, the social status of individuals is likely to be determined by the level of education and as a result, people pursue higher education. After the Second World War, modernization and Westernization started in Korea, as did science education. Despite short period of science education, Korean students performed well in international comparative study such as TIMSS 2003, in which they ranked third among 49 participation countries.

In contrast to Korea, South Africa is heterogeneous in terms of ethnicity, culture, and language. South Africa went through a long experience of colonization and thereby schools are characterized by poor resources. In particular, segregation and inequalities according to different racial groups created poorly funded and disadvantaged schools under apartheid. Such imbalances in education resulting from apartheid included teacher education. This was exacerbated by languages. Students suffered from both under-resourced schools and inconsistency between mother tongue and instruction language. As a result, South African students performed the worst in international comparative studies.

The large gap between Korea and South Africa in terms of science achievement leads to the problem statement, accounting for the difference. The study aims at exploring the factors that could account for the differences in science performance and proposed two research questions: To what extent does TIMSS 2003 reflect factors related to effective science education? To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students? The study is expected to contribute to increasing knowledge in terms of an international comparative study to compare an African country with an Asian country using the TIMSS data.

CHAPTER 2

BACKGROUND TO THE TIMSS 2003 STUDY

2.1 INTRODUCTION

The International Association for the Evaluation of Educational Achievement (IEA), an international, independent, and non-profit organization, has conducted international comparative studies including mathematics, science, and language since the 1960s. The ultimate goal of such studies is to identify the factors likely to influence student learning and help policymakers or educational practitioners manipulate them to improve student achievement around the world.

One of studies conducted by the IEA, the Trends in International Mathematics and Science Study (TIMSS), is a large scale international comparative study of student achievement in mathematics and science, conducted every four years from 1995. The studies were initiated to develop cross-national achievement tests and administer these with various educational systems.

One of the predecessors of TIMSS, the First IEA Science Study (FISS) was conducted during the 1970-1971 school year in eighteen countries (Comber & Keeves, 1973). The Second International Science Study (SISS) collected data from 23 countries from 1983 to 1984 (Postlethwaite & Wiley, 1992). The IEA conducted FIMS (the First International Mathematics Study) in 1964 with 12 education systems taking part. SIMS (the Second International Mathematics Study) was conducted in 1980-82 with 20 education systems participating (Travers & Westbury, 1989). The third IEA study in science was combined with an assessment of mathematics, conducted from 1995 to 1996, and was known as the Third International Mathematics and Science Study (TIMSS).

In 1999, the IEA repeated TIMSS to estimate trends in student achievement from 1995 at Grade 8, and it was called, appropriately, TIMSS-Repeat. From 1995 onwards, TIMSS has been conducted in a four-year cycle, and the first word of the acronymic title changed from “Third” to “Trends in” (International Mathematics and Science Study). Nearly fifty countries participated in TIMSS 2003, and nearly seventy in the most recently conducted study TIMSS 2007 (see Table 2.1, below).

TIMSS provides participating countries with an opportunity to gain various and comparative perspectives about their learners’ achievement in mathematics and science as well as the educational system. First, the regular cycle of TIMSS studies allows the participating countries to measure progress in educational achievement of mathematics and science. Secondly, the comparisons between achievements of countries may suggest reasons for differences. Thirdly, TIMSS can help each country enhance evaluation of the efficacy of mathematics and science teaching and learning. Lastly, TIMSS highlights growth in mathematical and scientific knowledge and skills from Grade 4 to Grade 8 (Mullis, Martin, Smith, Garden, Gregory, Gonzalez, Chrostowski & O’Conner, 2003).

Table 2.1 ***IEA Mathematics and science studies conducted from 1964-2007***

	Year	Number of countries	Population (grade)
FIMS	1964	12	8, final
FISS	1970-1971	18	4, 8, final[5]
SIMS	1980-1982	20	8, final
SISS	1983-1984	23 (Korea)	4, 8, final
TIMSS 1995	1994-1995	45 (Korea, SA)	4, 8, final
TIMSS 1999	1999	39 (Korea, SA)	8
TIMSS 2003	2003	49 (Korea, SA)	4, 8

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[5] 4, 8, and final mean the grade level intended to represent four, eight, and final years of schooling respectively.

TIMSS 2007	2007	68 (Korea)	4, 8

Besides the assessment of students' achievement in mathematics and science, TIMSS collects contextual data in the form of questionnaires. The questionnaires are administered to the student, teacher, school, and National Research Coordinators (NRCs) to provide comprehensive information about the context as well as the intended and implemented curriculum within the education system.

Data[6] provided about students' achievement in relation to different types of curricula or education systems, instructional practices and school environments has been a resource of secondary analyses in educational research fields (Howie & Plomp, 2006). The results have created many debatable issues nationally and internationally (Bracey, 1998; Wang, 1998a; Cheng & Cheung, 1999), with participating countries reconsidering their own curricula and introducing educational reforms (Reynolds, Muijs & Treharne, 2003).

Although TIMSS is designed to evaluate science as well as mathematics, most secondary analyses tend to focus on the latter (Bos, 2002; Howie, 2002; Papanastasiou, 2002; Ramírez, 2004; O'Dwyer, 2005). Although science and mathematics are closely related, there is a need to focus on science uniquely and to suggest possible interventions for the improvements to science education. Ideally, disappointing results of TIMSS could contribute to the development of more effective science education in participating countries (Duit & Treagust, 2003).

The rest of the chapter provides a general overview of TIMSS, in particular design issues and logic, instruments, and data quality, with the aim of providing a brief insight into the topic. Design issues are discussed in Section 2.2, design logic of TIMSS in Section 2.3, and, based on the design logic, instruments are

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[6] Although a Latin plural of datum, for grammatical purposes 'data' may also be used as an uncountable singular, as in this dissertation.

explored in Section 2.4. Finally, data transformation and data quality are explored in Section 2.5 and in Section 2.6 respectively.

2.2 DESIGN ISSUES REGARDING TIMSS

To address the TIMSS test, several global institutions were involved in the development of the instruments, administration of the test, and management of the data collected. This section shows briefly how the study was organized across 50 countries, how the objects were sampled, and how the data were collected.

2.2.1 ORGANIZATION OF TIMSS

Starting with 12 participating countries in 1964, there were 49 in TIMSS 2003, and 70 countries in TIMSS 2007, the latest. TIMSS is conducted under the auspices of the IEA, located in Amsterdam and controlled by three task forces, each responsible for a specific task. Firstly, the International Study Centre (ISC) is in charge of the design, development, and implementation of the study. More specifically, the Centre is responsible for the development of the assessment framework, assessment instrument and survey procedures, the certifying of the quality in data collection, the analysis of the data, and the reporting of the results. Secondly, the IEA Data Processing Centre takes charge of processing and verifying the data submitted by the participating countries, followed by the construction of an international database. Finally, Statistics Canada deals with collecting and evaluating the sampling documentation from the participating countries and calculating the sampling weights. In each participating country, a National Research Coordinator (NRC) and a national centre organize all aspects of TIMSS within that country (Martin, Mullis & Chrostowski, 2004).

2.2.2 SAMPLING

IEA studies mainly target all the students at the end of Grades 4 and 8, and the final year of formal schooling in the participating countries. Recently, the studies have focused on Grades 4 and 8 only. TIMSS 2003 had two target populations, but which grades participate in the test depends on each country's choice. The two target populations are defined as follows:

- Population 1: All students enrolled in the upper of the two adjacent grades that contain the largest proportion of nine-year-olds at the time of testing. This grade level was intended to represent four years of schooling, counting from the first year of primary or elementary schooling. It was Grade 4 in most countries.

- Population 2: All students enrolled in the upper of the two adjacent grades that contain the largest proportion of 13-year-olds at the time of testing. This grade level was intended to represent eight years of schooling, counting from the first year of primary or elementary schooling. It was Grade 8 in most countries (Martin Mullis & Chrostowski, 2004).

All participating countries were expected to define their *national desired populations* based on the definition of the *international desired populations* mentioned above. Each participating country used its national desired population to select its *national defined population*, which included at least 95 percent of the national desired populations, and the NRCs estimated the size of the target population to ensure it was as close as possible to the international target. In the process of sampling, there could be some exclusions, for instance, exclusions from national coverage; school-level exclusions, which could result from geographically remote regions or extremely small size; and within-school exclusions, which could occur due to intellectually disabled students or non-native language speakers (Martin, Mullis & Chrostowski, 2004).

At the first phase of sampling, stratification was made to group sampling units. Stratification improves the efficiency of the sample design, makes survey estimates more reliable, and ensures adequate representation in the sample of specific groups from the target population. TIMSS adopted a three-stage stratified cluster design, which selected a sample of schools from all those available, randomly selecting a science class from each sampled school, and sampling students within a sampled class. In addition, TIMSS involved explicit and implicit stratification. Explicit stratification involves separate sampling frames dependent on such stratification variables as geographic regions. This explicit stratification ensures disproportionate allocation of the school sample across strata. As opposed to explicit stratification, implicit stratification involves a single school sampling frame and sorts the schools in it according to a set of stratification variables. This stratification aims at ensuring proportional sample allocation, avoiding the complexity of explicit stratification as well as improving the reliability of survey estimates (Martin, Mullis & Chrostowski, 2004).

The selection of sampled schools was also carried out using a systematic probability-proportional-to-size (PPS) technique, as it is easy to implement and verify. The schools were listed by a measure of the size (MOS) of the sampling units corresponding to the number of students in the school in the target grade. The schools were sampled by the sampling interval given by dividing the total MOS by the number of schools to be sampled, and a random number in the range between 0 and the sampling interval. Sampled schools were all taken into consideration in terms of whether or not small they could increase sampling variance. Large schools could cause operational problems (Martin, Mullis & Chrostowski, 2004).

Once a school was selected, one classroom per school was sampled by means of PPS sampling within the schools. It should be noted that intact classes were sampled to analyze relationships between student achievement and teacher level data at the class level. When a sampled classroom was smaller than half the specified minimum cluster size, the classroom was combined with another classroom from the same grade and school. When a sampled class size was large, the fixed number of students was sub-sampled, using systematic sampling whereby all students in a sampled classroom were assigned equal selection probabilities (Martin, Mullis & Chrostowski, 2004).

2.2.3 DATA COLLECTION

TIMSS was administered near the end of the school year. Accordingly, countries in the Southern Hemisphere administered the test in October or November 2002, and countries in the Northern Hemisphere in April, May, or June 2003. The assessment booklets were organized into two sessions (Part I and II), having three item blocks respectively. These were administered to Grade 8 students in the sampled classroom for 90 minutes with a 20-minute break between the parts (Martin, Mullis & Chrostowski, 2004).

Each participating country carried out all aspects of the data collection using standardized procedures developed for the study and based on training manuals created for school coordinators and test administrators. A Quality Control Monitor (QCM) was appointed by the TIMSS & PIRLS International Study Centre to monitor compliance with standardized procedures for their countries. The QCM interviewed the NRC in each of the participating countries and visited the 15 sites (schools) sampled, observing the participants during the test administration.

After the administration of the TIMSS 2003 assessment, the NRC in each country dealt with the procedures of scoring the constructed-response items to ensure reliability of scoring. The data scored in each country was submitted to the IEA Data Processing Centre for verification, and the construction of an international database.

2.3 RESEARCH DESIGN

The design for TIMSS is based on a conceptual framework developed by TIMSS for the international studies. The framework is specific to mathematics and science in TIMSS and the instruments were developed according to it. The focus of exploration is placed on the TIMSS curriculum model in Section 2.3.1 and the science framework in Section 2.3.2, but not the mathematics framework.

2.3.1 THE TIMSS CURRICULUM MODEL

TIMSS has examined the schooling system from a curriculum point of view to explore how educational opportunities are provided to students, how students use these opportunities, and which factors operate across them. Since SIMS, TIMSS has developed a curriculum-based conceptual framework which includes three levels, viz., the intended, implemented, and attained curricula, as shown in Figure 2.1 (below). The three-dimensional curriculum model indicates what students need to learn, how educational systems should be arranged to promote student's effective learning, what is actually taught in classroom by whom, and how, and what students have learned and their attitudes towards mathematics and science (Mullis et al., 2003).

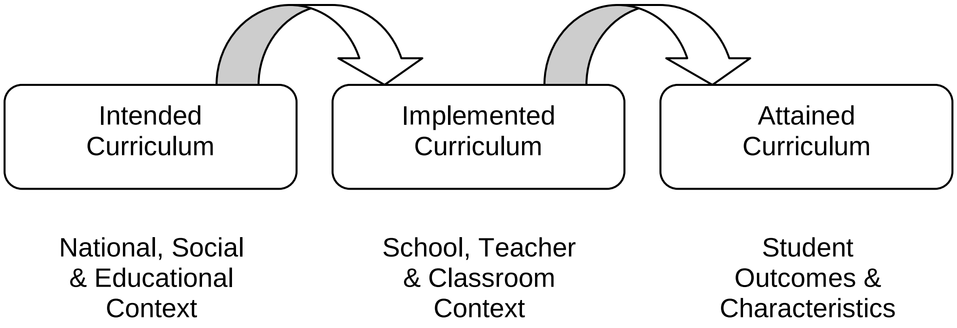

Figure 2.1 **TIMSS curriculum model (Mullis et al., 2003, p.3)**

The intended curriculum reflects society's request for teaching and learning in mathematics and science, and an educational system tends to plan it for a specific subject at the contextual level. The intended curriculum can be materialized in the form of curriculum documents that identify goal statements, prescribed textbooks, syllabi, evaluation policy, and other educational resources.

The implemented curriculum is about what is actually taught in the classroom, that is the intended curriculum as interpreted and translated by teachers in the classroom at school level. Teachers tend to carry out the intended curriculum according to their experience and beliefs regarding the subject. The classroom is the place where teaching and learning happens and teachers decide what is actually taught.

The attained curriculum is what students have learned, and includes the attitudes towards subjects. It may be evaluated by performance tests, the results of which ensure feedback to inform improvement of the intended or implemented curriculum. Ultimately, the attained curriculum is the main focus of many international comparative studies, such as TIMSS.

Based on the curriculum model described above, work to update the frameworks was carried out in line with a review of the TIMSS 1999 curriculum data to identify mathematics and science topics emphasized in the curricula of the TIMSS countries. In addition, the TIMSS framework includes contextual factors influencing students' learning in mathematics and science, and is discussed in the following section.

2.3.2 THE TIMSS SCIENCE FRAMEWORK

As stated above, TIMSS assesses mathematics and science separately. The starting point was mathematics, with science being built on the basis of the mathematics framework operation. Taking a brief look at the mathematics framework as a reference for science, the assessment framework for TIMSS 2003 was structured by two organizing dimensions, content and cognitive, corresponding to those used in the earlier TIMSS assessments. The content dimension consisted of five domains, namely number, algebra, measurement, geometry, and data. The cognitive dimension comprised four domains, i.e., knowing facts and procedures, using concepts, solving routine problems, and reasoning.

The science assessment framework for TIMSS 2003, as in the mathematics framework, includes the two organizing dimensions though here the five content domains are life science, chemistry, physics, earth science, and environmental science. The cognitive dimension encompasses three domains, namely factual knowledge, conceptual understanding, and reasoning and analysis (Martin, Mullis & Chrostowski, 2004). From 2003 on, TIMSS has placed more emphasis on questions that draw out students' analytical, problem-solving, and inquiry skills and capabilities (Mullis et al., 2003). The assessment framework explored above forms a basis for the instruments presented in Section 2.4.

2.4 INSTRUMENTS

Instruments addressed in TIMSS 2003 consisted of mathematics and science achievement test items, as well as questionnaires. The achievement test was designed to assess mathematics and science knowledge and skills based on school curricula for Grade 8 learners. The assessment items were developed, dependent on the contribution of NRCs during the entire process, and based firmly on the assessment frameworks and specifications to ensure validity and reliability (Martin, Mullis & Chrostowski, 2004). The survey questionnaires were based on many factors derived from research on effective schools.

2.4.1 SCIENCE ASSESSMENT

The assigned testing time for science content is as follows: 30% for life science, 25% for physics, and 15% each for chemistry, earth science, and environmental science. Each content area has several topics (Mullis et al., 2003).

Taking a brief look at the topics of each subject domain, *life science* includes the following topics: types, characteristics, and classification of living things; structure, function, and life processes in organisms; cells and their functions; development and life cycles of organisms; reproduction and heredity; diversity, adaptation and natural selection; ecosystems; human health. Even though TIMSS specifies a separate human biology topic area, the aforementioned are all related to human biology (Mullis et al., 2003).

While both *chemistry and physics* are incorporated in physical science at Grade 4, these two areas are assessed separately at the Grade 8 level. Chemistry assesses students on the following topics: classification and composition of matter; particulate structure of matter; properties and uses of water; acids and bases; chemical change. Physics places focus on the concepts related to energy and physical processes, with students being assessed on the following topics: physical states and changes in matter; energy types, sources, and conversions; heat and temperature; light; sound and vibration; electricity and magnetism; forces and motion (Mullis et al., 2003).

It is clear that *earth science* is focused on the earth and its place in the solar system and wider universe. However, earth science is complicated since it is related to various fields, such as geology, meteorology, physics, and astronomy. As such, some of the earth science topics are taught in subjects other than science. Although there is no single picture of the earth science curriculum, TIMSS seeks to assess such concepts common across countries, such as the earth's structure and physical features; the earth's processes, cycles, and history; the earth in the solar system and the universe (Mullis et al., 2003).

Environmental science is concerned with understanding related to the interaction of humans with ecosystems, changes in the environment from manmade or natural events, and protection of the environment. It emphasizes the roles and responsibilities of science, technology, and society to maintain the environment and conserving resources. The topics covered in the test are listed as follows: changes in population; use and conservation of natural resources; changes in environments (Mullis et al., 2003).

The cognitive dimension of the assessment focuses on student skills and abilities, defined as the sets of behaviours expected of students as they are involved in science content. There are three cognitive domains: factual knowledge, conceptual understanding, and reasoning and analysis. Firstly, *a factual knowledge* base of relevant science facts, information, tools, and procedures is fundamental to execute the more complex cognitive activities in science. In order to assess factual knowledge, items can ask students to recall or recognize science facts and concepts, demonstrate scientific terms, tools, and procedures, or describe scientific properties and relationships (Mullis et al., 2003).

Secondly, *conceptual understanding* is based on factual knowledge and can be indirectly assessed by asking students to use models to illustrate structures and relationships and demonstrate scientific concepts to solve problems. The activities measuring conceptual understanding are listed as follows: illustrate with examples; compare, contrast, and classify; represent and model; find relationship between underlying concepts and observed properties; extract and apply information (Mullis et al., 2003).

Lastly, *reasoning and analysis* requires more complex tasks than the two domains mentioned above. It involves some problem-solving situations unfamiliar to students and perhaps a little more complicated. Therefore, students may be requested to analyze the problems, to select and apply the appropriate equations or formulae to solve the situation, to hypothesize or predict. Activities related to reasoning and analysis are listed as follows: to analyze, to interpret, to solve the problems; to integrate and to synthesize; to hypothesize and to predict; to design and to plan; to collect; to draw conclusions; to generalize; to evaluate; to justify solutions found (Mullis et al., 2003).

Scientific inquiry has been emphasized in contemporary science since scientific literacy becomes important as technology develops. Scientific inquiry is associated with ‘doing science’ such as demonstrating, applying and using knowledge. Items that assess scientific inquiry ask students to involve the processes of scientific investigation and draw out some of the skills related to scientific inquiry in a practical context. Therefore, students are requested to explain cause and effect or relationships between variables. The items and tasks for scientific inquiry are set in content-based contexts without being classified separately. Specifically for Grade 8, scientific inquiry items were selected from topics such as ‘life in the oceans’ and ‘Galapagos islands’ from life science and ‘metal crown’ from the physics and chemistry domains.

In terms of question types, TIMSS uses two kinds of formats, viz., multiple-choice questions and constructed-response questions (Martin, Mullis & Chrostowski, 2004). Multiple-choice questions are assigned 54% of score points, and constructed-response 46%. It is expected that the latter questions are better suited than the former for asking students to explain or interpret data than for testing students’ knowledge or experience.

In addition to the 109 multiple-choice science questions are 80 constructed-response questions, consisting of 59 short-answer items and 21 extended-response items. All of these items are divided into 14 item blocks labelled S01 through S14. Six of the blocks contain trend items from 1995 and 1999 and eight blocks include new items developed for TIMSS 2003. Each block is composed of

8-9 multiple-choice items, 3-4 short-answer items, and 1-2 extended-response items, and accordingly, the total number of items per block ranges from 11 to 16 (Martin, Mullis & Chrostowski, 2004).

There are additional 14 item blocks for mathematics named M01 to M14 in the same way, making 28 item blocks in total. Among both the 14 mathematics and 14 science blocks, six item blocks form one student booklet, with 12 different student booklets consisting of six item blocks respectively. Participating students complete just one booklet.

2.4.2 QUESTIONNAIRES

TIMSS also aims to understand the context in which students learn, to improve students' learning in science and test their achievement in science. TIMSS designed questionnaires to provide a context for the performance scores, focusing on students' backgrounds and attitudes towards science, the science curriculum, teachers of science, classroom characteristics and instruction, school context and instruction (Martin, Mullis, Gonzalez & Chrostowski, 2004). The survey for the contextual information was based on factors identified from the findings of educational research.

All questionnaires relied on self-reported information based on Likert-type scales, and stratified on four levels: curriculum, school, teacher, and student. The purpose of these questionnaires was to gather information about five broad areas, viz., curriculum, school, teachers and their preparation, classroom activities and characteristics, and students at various levels of the educational system (Mullis et al., 2003).

The curriculum questionnaire has four versions, viz., mathematics and science for Grade 4 and for Grade 8 respectively, however all are very different in terms of structure and content. The curriculum-related questionnaire is based on the formulation and organization of the curriculum, defining its scope and content, the monitoring and evaluation of the implemented curriculum, and curricular materials and support. A curriculum formulated in a country tends to reflect the societal value or attitudes towards science education, the resources available for education, and the degree of attainment expected in conjunction with the economic level of a nation (Mullis et al., 2003).

Curricular documents define the scope and content of the curriculum in the form of the knowledge, skills and attitudes for students to be acquired through education offered in a country. However, the degree or the way the goals of curriculum are achieved varies across countries. In addition, organization of the curriculum, such as a decision to teach science as separate subjects or as a single subject, can influence the student learning experience. On the other hand, the curriculum implemented in schools can be monitored or evaluated by the way of standardized tests, school inspection, and audits. When implementing the curriculum, it can be supported by training teachers or by the development and use of teaching materials, such as textbooks (Mullis et al., 2003). Accordingly, the questionnaire related to curriculum seeks to assess all these points mentioned above.

The school questionnaire has two versions, one for Grade 4 and another for Grade 8, but they do not really differ. The school questionnaire covers the school-quality-related issues such as school organization, school goals, roles of the principal, resources to support science learning, parental involvement, and a disciplined school environment. Many factors identified from the research influence student learning and achievement at the school level, for example, whether or not schools are tracked, and if they have either an academic or vocational curriculum. The time allocated for science education at the school level can also influence student learning. Research indicates that schools articulating such goals as literacy, academic excellence, personal growth, good work habits, and self-discipline, tend to perform better than others. The leadership of the school principal is reported to be associated with student achievement. General resources like teaching materials, budget for supplies, school buildings and classroom space, and subject-specific resources including computers and laboratory equipment may influence student learning. A high degree of parental involvement, including checking homework, volunteering for field trips and fund raising, can influence academic performance. Similarly, a safe and orderly school environment is important, considering that being absent or late to class decreases time for study and reflects negative attitudes towards schooling (Mullis et al., 2003).

The teacher questionnaire is designed to be addressed to the classroom teacher of the sampled class. It has two parts, viz., information about teachers and their preparation, and classroom activities and characteristics (Mullis et al., 2003). Considering that teachers are the direct operators of curriculum implementation, teacher and classroom characteristics are the most important factors influencing student learning. Specifically, qualification of science teachers has been regarded as an important factor since science instruction is involved in many more counterintuitive scientific concepts than in other subjects (Brophy & Good, 1986). Items related to teachers and identified as important include academic preparation and certification, recruitment, assignment, induction, teacher experience, teaching styles, and professional development. Research shows that all of these factors are considered as influencing student achievement.

Also included are classroom activities and characteristics and include effective-learning-related issues such as curriculum topics taught, instructional time, homework, assessment, classroom climate, use of information technology, emphasis on scientific investigation, and class size (Mullis et al., 2003). Specifically, computers have changed the ways concepts are explored, which has not been the case in the past. Reflecting the importance of teachers' academic skills and the rapid growth in information technology (IT), teacher preparation and professional development, and the use of technology were added to TIMSS 2003 (Martin, Mullis & Chrostowski, 2004).

The student questionnaire is concerned with home background and resources for learning, prior experiences, and attitudes toward learning, all of which are recognized as influential factors emanating from research. Research shows that student background is most likely to influence student achievement. Home background factors influencing achievement can be indirectly measured by investigating the number of books in the home, availability of a study desk, the educational level of the parents, the presence of a computer, and the extent to which students speak the language of instruction. In addition, students' attitudes toward schooling or science are seen as important to their learning (Martin, Mullis & Chrostowski, 2004).

Some parallel questions are used to measure the same construct from different sources. Student questionnaires consist of 23 items, some of which also have sub-categories. Teacher and school questionnaires are made up of 34 and 25 items respectively and various sub-items constitute item sets. Student, teacher, and principal questionnaires for Grade-8 science, which are data for the current research, can be referred to in Appendix B, C, and D.

2.5 DATA TRANSFORMATION

TIMSS seeks to broadly cover the science curriculum and to measure trends across assessments, and thus necessitated a matrix-sampling booklet design, in which individual students respond to only a subset of items in the assessment rather than the entire set. For this purpose, TIMSS adopted Item Response Theory (IRT), and calculated the achievement scores using IRT methods with a scale of 800 points and a standard deviation of 100 points. Although different samples of students took different blocks of items, performance could be compared across countries, as the IRT analysis provided a common scale (Mullis et al., 2003).

IRT can be considered item-free person ability measures and person-free item difficulty measures. Accordingly, although all of test takers do not answer the same items, IRT can ensure that their results are comparable (Nakamura, 2001). Under IRT, the individual item of a test is highlighted as opposed to the raw test score focused on under classical test theory. IRT can be formulated with three item parameters, viz. difficulty, discrimination, and guessing parameter depending on a logistic function model used. Difficulty as a location index indicates a point on the ability scale where the probability of correct response is 0.5 as opposed to being relative to a group of examinees under classical test theory. The discrimination parameter indicates how well an item can differentiate between examinees having a latent trait tested in question and those not having. However, it is clear that high discrimination does not mean good validity of an item and it has nothing to do with ability itself (Baker, 2001). Lastly, the guessing parameter reflects the possibility of getting the item correct by guessing alone in multiple choices.

IRT has some basic principles compared to classical test theory. Firstly, these parameters rely on items themselves, not the group tested with them. The two groups, which are at different ability levels, produce the same values of the item parameter. However, under classical test theory, these parameters rely on the ability level of the examinees responding to the items. Secondly, the examinee’s ability is not dependent on the items used to determine it. Therefore, the examinee’s ability does not vary with respect to the items used. In contrast, under classical test theory an examinee tends to get a high score on the easy test and a low score on the difficult one (Baker, 2001).

TIMSS 2003 used three distinct IRT scaling models according to item format and scoring procedures when analysing the assessment data. A three-parameter model was used for the multiple-choice items and a two-parameter for constructed-response items with only two response options.

TIMSS used a matrix-sampling design that makes each respondent test part of all the items covering a wide range of contents. The matrix-sampling method makes it possible for population characteristics to be estimated more efficiently, but cannot make precise statements about individuals. In order to offset this drawback, plausible values methodology was used in TIMSS. Even though plausible values are not the best option to explain an individual's proficiency, they estimate population characteristics consistently. By having the students' responses to the items, the item parameters calibrated, and the conditioning variables, TIMSS produced the plausible values for student proficiency. TIMSS produced five plausible values for each sampled student, the variation indicating an uncertainty associated with proficiency estimates for individual students. These plausible values were offset by information about students' background gained through the process of conditioning, in order to enforce the reliability of the student scores.

In summary, TIMSS calibrated the achievement test items estimating model parameters for each item and created principal components from the questionnaire data for the conditioning procedure. Subsequently, IRT scale scores were generated for mathematics and science and for each content domain. Finally, the proficiency scale scores were placed on the metric used in the previous assessment and the average of the mean scores was set to 500 and the standard deviation to 100.

2.6 DATA QUALITY

Examining reliability and validity is very commonly accepted when quality in educational measurement is considered. Reliability concerns the consistency of measurements and implies internal consistency, equivalence, and stability, while validity involves the credibility of results and contains predictive and concurrent validity, content-related validity, and construct validity. These two criteria, viz., reliability and validity, contribute mainly the generalisability of the results which come from the measurement addressed (Scherman, 2007).

2.6.1 VALIDITY CONSIDERATIONS IN TIMSS

To ensure the quality of the data to be collected in survey research, there are two characteristics of importance: reliability and validity. Validity refers to the inferences about "the adequacy of a scale as a measure of a specific variable" (DeVellis, 1991, p.43). As far as validity is concerned in quantitative research, it is suggested that careful sampling, appropriate instrumentation, and appropriate statistical treatments of the data can improve data validity (Cohen, Manion & Morrison, 2007).

There are several types of validity typically assessed in survey research, including content validity, criterion-related validity, and construct validity. Content validity indicates how well items measure what is intended to be covered, and in order to ensure this, items should be sampled carefully (Cohen et al., 2007). Therefore, it is assessed by experts in some aspect of the subject. Criterion-related validity involves predictive validity and concurrent validity (Gay & Airasian, 2003). Predictive validity is concerned with another instrument being administered in the future, while concurrent validity can be measured by collecting data at the same time but in different ways, such as observations, interviews, and surveys (Cohen et al., 2007). It can be said that TIMSS attempted to partly achieve concurrent validity by administering triangulation questionnaires shown in student, classroom, and school levels. Construct validity indicates theoretically how meaningful a survey instrument is, and tends to be determined after years of experience by numerous investigators (Litwin, 1995). Therefore, ensuring or building construct validity is regarded as gathering a variety of evidence to support validity, but this is not a simple process (Gay & Airasian, 2003). Specifically, 'discriminant validity', involved in researching different constructs, can be investigated by factor analysis (Cohen et al., 2007).

In particular, TIMSS placed emphasis on content validity in the process of the development of the instrument. To ensure content validity of the assessment instrument, TIMSS 2003 made a tremendous effort in developing items. To begin with, the international item pool was developed and aligned with the assessment framework. Participants from more than 30 countries and each national research centre conducted this work. In the case of science, each draft item was classified according to whether or not it was intended to measure knowledge or skills associated with the scientific inquiry strand. Finally, an initial item pool covering a broad range of science topics was developed. The initial item pool was examined, complemented, and screened in subsequent review by the mathematics and science task forces. The next review was carried out by the item review committee, along with a group of experts, then reviewed once more by the item review committee. Field-tests were also administered to representative samples of students in each country. The NRCs were involved and contributed to the development at every stage. The final forms of the test, endorsed by the NRCs, had an opportunity to be assessed by test-curriculum matching analysis to investigate the appropriateness of the TIMSS 2003 test for students in the participating countries. The results have shown that, generally, the proportion of the items judged appropriate was high (Martin, Mullis, Gonzalez & Chrostowski, 2004).

2.6.2 RELIABILITY CONSIDERATIONS IN TIMSS

Opposed to validity, that concerns the judgements about how adequate a scale is to measure a specific variable, reliability indicates how stable measurement is over time and over similar samples. In particular, in quantitative research such as used for this study, it is argued that reliability is correspondent to dependability, consistency, and replicability over time, over instruments, and over groups of respondents (Cohen et al., 2007). There are several kinds of reliability to be used in research: test-retest reliability, split-half reliability, and internal consistency reliability. In TIMSS, they also included items that had been used in the 1995 and 1999 assessments in order to ensure reliable measurement of trends over time. As a result, 74 in science, including both multiple-choice and constructed-response items, are trend items addressed in 1995 and 1999 at Grade 8.

As another way to enforce test reliability, TIMSS developed many items (383) for the assessment to be more reliable, and designed the survey using a matrix-sampling technique. Here, each item was assigned to one of a set of item blocks to ensure broad subject-matter coverage preventing overburdening of students which could decrease reliability. Since sampled students did not take the same items, TIMSS estimated student achievement using the IRT scaling method, where students' scores do not depend on using the same set of items. To improve reliability of the scaling method, TIMSS used an approach known as 'conditioning', where reliable scores are produced even though individual students respond to relatively small subsets of the total item pool.

Furthermore, TIMSS was concerned with 'inter-rater reliability' in relation to scoring the constructed responses. A back-reading process was conducted to monitor scoring reliability and a random sample of more than 100 booklets, scored independently, was compared to establish the reliability of the scoring within each country. In 2003, some student-constructed responses from 1999 were rescored to provide scoring reliability over time (Martin, Mullis & Chrostowski, 2004). As a result, Cronbach's alpha scoring reliability coefficient was as high as 0.84 in the science test overall. In particular, it was 0.87 for Korea and 0.84 for South Africa (Martin, Mullis, Gonzalez & Chrostowski, 2004).

2.7 CONCLUSION

Since 1995, the IEA has conducted global studies in science and mathematics every 4 years. The studies also include surveys to collect information about the educational system in terms of that subject. For the study, the IEA developed its own conceptual framework and instruments. The study consists of two parts including assessment and questionnaires. The assessment is with respect to science subjects and questionnaires survey for the educational background information for the students tested. TIMSS has focused on student achievement at two populations, viz., Grade 4, and 8. Data is collected at the end of the school year in each country.

Since TIMSS aims at broadly covering the science curriculum and measuring trends over years, IRT was involved in assessment design and as such a matrix-sampling booklet was issued to each student to eliminate concern about examinees' difference in terms of achievement. Data collected was finally scored and processed within the requirements of validity and reliability. TIMSS intends to get a picture of education in the subject in question and find out the strengths and weaknesses, and ultimately inform policy changes in curriculum or instructional practice.

CHAPTER 3

RESEARCH ON FACTORS INFLUENCING STUDENT PERFORMANCE

3.1 INTRODUCTION

In this chapter, factors influencing student performance, in particular science achievement and school effectiveness research (SER) are examined. Policymakers around the world need to be able to measure the effectiveness of the education on offer in their countries, and this can be appraised by measuring outcomes gained by students. Therefore, it is not surprising that outcomes of education have been the focus of education research over the past decades. Many factors influencing student outcomes were identified at a similar time as the formulation of the SER field. By identifying effective factors, along with effective schools, researchers have developed school effectiveness models based on findings and evidence, and applied these to school improvement projects. These will be explored in this chapter.

SER is inextricably linked with teacher effectiveness research (TER) as the two areas both aim to improve student achievement. Nonetheless, SER conducted thus far has taken place mainly in developed countries, using mathematics or language achievement as a dependent variable. To address this weakness, research should be undertaken in developing countries, also investigating achievement in learning areas of particular importance to their development, for instance science. This chapter provides some background information on SER, as a conceptual framework for the study based on school effectiveness models, and reflects on effective factors related to science achievement of students. In

Section 3.2, the literature on SER is reviewed, followed in Section 3.3, by factors related to science achievement. Conclusions are drawn in Section 3.4.

3.2 SCHOOL EFFECTIVENESS RESEARCH

In this section, the historical background of SER is explored in relation to models on the development of evidence-based school effectiveness. The contribution made by SER in school improvement is examined and teacher effectiveness reviewed in the light of SER. Finally, an argument is made for SER in developing countries, particularly in science subjects.

3.2.1 THE HISTORY OF SCHOOL EFFECTIVENESS RESEARCH

SER has formed a considerable part of education research since it started in the USA in the mid-1960s (Teddlie & Reynolds, 2000). Early school effectiveness research, such as that conducted by Coleman et al. (1966), showed that school made little difference in terms of student achievement when compared to family factors. The studies conducted under the auspices of the IEA between 1966 and 1973 supported Coleman et al.'s argument (1966), resulting in a similar finding that schools had little bearing on student achievement (Walker, 1976).

However, in reaction to such a diminished view of school effectiveness, many studies were conducted which reported that schools do in fact have an impact on student achievement. Comber and Keeves (1973), examining the Second International Science Study (SISS) data, found that opportunities to learn, mostly determined by schooling, had a strong impact on student achievement in science. They contended that it is not possible to detect weak but consistent and cumulative effects of schooling at any single point in time, whereas strong family effects are more easily identifiable (Comber & Keeves, 1973). Coleman (1975) who earlier initiated SER, later reported in the secondary analysis of the IEA studies that school effectiveness varies across countries and subjects, and it does mean that schools matter and have an influence on student achievement.

In another response to the results of Coleman et al.'s report (1966), effective schools were investigated in an attempt to identify the common characteristics that make some schools more effective than others (Scheerens, 1992). The findings identified five-factors within effective schools, including strong educational leadership, emphasis on acquiring basic skills, an orderly and secure environment, high expectations of pupil attainment, and frequent assessment of pupil progress (Edmonds, 1979). A meta-analysis of the previous literature undertaken by Walberg (1990) identified nine factors which influence educational productivity from a comprehensive psychological perspective. These factors were the ability or prior achievement of students, biological development, motivation, quantity of instruction, quality of instruction, home environment, classroom or school environment, peer group environment, and mass media environment. He excluded such organizational factors of schools as size, and individual characteristics such as gender, as these factors are less alterable. More comprehensively, Scheerens and Bosker (1997), drawing on school effectiveness studies conducted mainly in 1990s, listed the most commonly mentioned factors as:

- Achievement orientation, high expectations, teacher expectations,
- Educational leadership,
- Consensus and cohesion among staff
- Curriculum quality, opportunity to learn
- School climate
- Evaluative potential,
- Parental involvement,
- Classroom climate

- Effective learning time (classroom management),
- Structured instruction,
- Independent learning,
- Differentiation, adaptive instruction
- Feedback and reinforcement

The findings from SER explored above could be applied to other areas such as school improvement programmes (Clark & McCarthy, 1983; McCormack-Larkin, 1985). Findings emerging from SER have thus been used in two ways: to identify and measure the indicators of school monitoring (Barr & Dreeben, 1983; Shavelson, McDonnell & Oakes, 1989; Mulford, 1988; Zuzovsky & Aitkin, 1990; Suter, 1995; Fitz-Gibbon, 1996; Mayer, Mullens, Moore & Ralph, 2000), and to develop an understanding of factors within SER which may contribute to the building of a conceptual framework (Scheerens, 1990; Stringfield & Slavin, 1992; Creemers, 1994). An economic-driven input and output paradigm tends to involve such school resources as expenditure per pupil and student characteristics such as socio-economic status (SES), but it does not include classroom or school processes. In contrast, taking into consideration the process factors leads to another framework, namely instructional effectiveness theory.

The most adopted theory of instructional effectiveness is Carroll's school learning theory, which consists of five factors all linked to the use of time (Carroll, 1963). Together with considering instructional effectiveness, the economic input-output paradigm was translated into an organizational paradigm, concerned with the hierarchical and multivariate nature of the school system (Zuzovsky & Aitkin, 1990). In addition, statistical progress (or computer development), such as multilevel analysis technique which assesses more accurately the effects of all levels, made this evolution possible. Along with the development of multilevel modelling, the early 1990s saw the development of integrated and multilevel educational effectiveness models based on literature (Scheerens, 1990; Stringfield & Slavin, 1992; Creemers, 1994). Such comprehensive models of school effectiveness as Creemers', Scheerens', and Stringfield and Slavin's include contextual, organizational, instructional conditions or factors presumed to enhance educational performance (Scheerens, 1992). All these aspects work towards developing the theoretical underpinning of SER.

Some research tested the conceptual models discussed above to offer empirical evidence (Reezigt, Guldemond & Creemers, 1999; Kyriakides, Campbell & Gagatsis, 2000a; 2000b; De Jong, Westerhof & Kruiter, 2004). Creemers' model has been tested against integrated and multilevel educational effectiveness models (discussed below). However, findings from research do not always support Creemers' model, including those of Reezigt et al. (1999), who tested its main assumptions on the expected effects on student achievement of individual classroom and school level factors in language and mathematics in primary school in the Netherlands. The results showed inconsistency across the subjects, and that time for learning and opportunity to learn, which are essential factors in Creemers' model, had negative effects attributable to the mismatch of the language and mathematics tested and the actual content taught by the teachers. The study implies that the possibility of different effective factors not presented in Creemers' model should be considered (Creemers, Scheerens & Reynolds, 2000).

Kyriakides et al. (2000b), using Creemers' model, reported on mathematics in a Cypriot primary school. This study revealed less disappointing results, although time on task and the quality of instruction showed little correlation with student achievement. However, the results did show multilevel influences on achievement and that the effect of the classroom was greater than that of the school, thus arguing for the importance of learning contexts. On the other hand, attention should be given to the finding of inconsistency across subjects in primary school, as in Reezigt et al. (1999), and educational effectiveness should be studied according to systems or subjects, just as effective teacher behaviour should be qualified in different grades or contexts (Brophy & Good, 1986).

De Jong et al. (2004) added to the validity of the main concepts in Creemers' model in conducting a study of mathematics in the first year of lower general education in the Netherlands. Their findings were more improved than previously seen, and revealed that time spent, opportunity to learn, and quality of instruction were strong predictors of achievement. Kyriakides (2005) tested the validity of Creemers' model in different criteria such as mathematics, Greek language, and affective aims, assuming the considerable unexplained variance at student level might be attributed to some variables that should have been included in Creemers' model. The results of Kyriakides' study, adding psychological factors such as personality and styles of thinking to the student level, showed a decrease in the unexplained variation from 24.3% to 17.6%.

The three studies examined above, viz., Reezigt et al. (1999), Kyriakides et al. (2000b), and De Jong et al. (2004), revealed that selection and collection of data related to factors in the model were important, however all reveal some shortcomings and weaknesses. Reezigt et al. admit data of the key factors, for instance, time for learning or opportunity to learn, were collected imperfectly. Kyriakides et al. depended only on questionnaires and De Jong et al. used only ethnicity and gender as social context variables for reasons of privacy, which are not considered adequate. Reflecting on this weakness, Kyriakides (2005) used 11 well-trained observers to measure factors related to quality of teaching, and the results showed factors related to teachers were more likely to influence student achievement.

As explored above, studies to test the school effectiveness models are still rare, therefore further studies, such as this secondary research, need to be undertaken in order to gain evidence-based support and give wider and deeper insight into the school effectiveness models, for instance the current study on the teaching of science in developing countries.

3.2.2 SCHOOL EFFECTIVENESS RESEARCH AND SCHOOL IMPROVEMENT

School effectiveness models based on identified effective factors and newly developed multilevel modelling, in turn, motivated some school improvement research (Teddlie & Stringfield, 1993; van der Werf, Creemers & Guldemond, 2001). The main aim of SER is to identify malleable factors to influence student achievement so that policymakers may manipulate the factors by appropriate reform projects. Therefore, the approach and knowledge base of school effectiveness could be used for school improvement and development of education systems (Scheerens, 2001). The empirical evidence of school effectiveness based on the recently developed conceptual models is still controversial and under development, however could be covered by evaluative, monitoring programmes, and reform projects, aimed at educational improvement (Muijs & Reynolds, 2000; Van der Werf, Creemers, de Jong & Klaver, 2000; Peng, Thomas, Yang & Li, 2006). It has been proposed by Reezigt and Creemers (2005) that there is a link between two areas, namely SER and school improvement, and they attempted to formulate a theoretical framework of school improvement based on a school effectiveness model. In contrast to the focus on classroom level in school effectiveness, they pointed out that the school level process tends to occupy a central position in the framework, based on effectiveness and improvement theories. This integration could result in enforcement of experiment-based evidence (Creemers, 2002; Creemers & Reezigt, 2005).

One can see more powerful results from the improvement project based on the conceptual frameworks of SER in the following examples. Teddlie and Stringfield (1993) suspected generalization of the five factors, identified in light of equity issue in 1970s, and studied effective schools across different contexts, such as low, middle and high SES, primary and secondary schools, and rural and urban areas in the Louisiana School Effectiveness study. Their findings, gathered from classroom observation, gave some insight into school improvement efforts related to teacher evaluation. Houtveen, van de Grift and Creemers (2004) conducted action research to find out if the Mathematics Improvement Program (MIP), developed from the perspective of constructivist teaching and Creemers' ideas about school effectiveness, was effective in Grade 3 of the Netherlands. The results of adaptive instruction of mathematics supported the overall positive effect of the programme, resulting in a considerable decrease of students struggling with the subject. In addition, their multilevel analysis showed that 15% of the variance in student results could be explained at the school level. These findings imply that SER can contribute to a school improvement programme.

3.2.3 SCHOOL EFFECTIVENESS RESEARCH AND TEACHER EFFECTIVENESS

SER tends to merge with instructional, or teacher effectiveness, depending more on classroom level and especially teachers' behaviour within classroom (Scheerens & Bosker, 1997; Scheerens, Bosker & Creemers, 2000; Reynolds et al., 2003). The merging of SER and TER has occurred across countries (Reynolds et al., 2002; Ellett & Teddlie, 2003; Lee, Lam & Li, 2003; Reynolds et al., 2003). The two areas are similar in that the aim of the two research areas is to identify effective factors and to improve student achievement.

Muijs and Reynolds (2000) concentrated specifically on effective teaching behaviour of teachers in mathematics classes in the UK, examining nine effective teachers together with classroom organization, and reflecting the cumulative impact of various forms of effective teaching behaviour (Sweeney, 2003). It is of interest that whole-class interactive teaching, predominant in mathematics classes in Eastern Asian countries, was introduced in the study. Multilevel analyses showed that between 60% and 100% of pupil progress on the numeracy tests was accounted for by teacher behaviour, and confirmed the relation of teaching factors with student achievement. The study concluded that whole-class interactive teaching contributes indirectly to student progress in the way that effective teaching behaviour depends on both time on task and classroom organization, and time on task, in turn is influenced by classroom organization related to whole class interactive teaching.

Traditionally, teacher effectiveness has been studied with respect to student cognitive outcomes (Brophy & Good, 1986). Recently, the need for multiple criteria for measuring SER has been raised in reaction to achievement having been the only outcome variable focused on thus far (Teddlie & Reynolds, 2000; Konu, Lintonen & Autio, 2002), and a multi-faceted teacher role has been explored reflecting the function of the school in the globalising world (Kyriakides, Campbell & Christofidou, 2002; Muijs, Campbell, Kyriakides & Robinson, 2005). Opdenakker and Van Damme (2000) researched coherence and consistency among teachers and teacher instruction, including staff co-operation, and found the relative influence of classes and schools on achievement was much higher than the influence on wellbeing.

Campbell, Kyriakides, Muijs and Robinson (2004) illustrated that teacher effectiveness, incorporating moral values, demanded independent learning and a classroom climate associated with teacher effectiveness. By the same token, Muijs et al. (2005) pointed out in their study into differentiated teacher effectiveness across different domains, such as cognitive or affective area, that teacher factors should encompass affective aspects as well as cognitive ones related to student learning. For example, teachers' high expectation towards students can facilitate and raise students' self-concepts. Kyriakides, Charalambous, Philippou and Campbell (2006) explored teachers' attitudes toward mathematics reform introduced in Cypriot primary schools recently, and reported that teachers with high efficacy beliefs held more positive attitudes towards reform and are more likely to implement it. Considering that teacher behaviour is based on their attitudes or belief, relationships between teacher behaviours and attitudes should not be ignored. The most recent study conducted by Hattingh et al. (2007) in South Africa, showed that teachers' perceptions of their learners influence their use of practical work in science classes. As shown in the many studies above, it cannot be overstated that teacher effectiveness is a vital factor in influencing student learning and achievement.

For that reason, policymakers need to improve the quality of teachers through training or evaluation programmes that include changes in approach to the curriculum, as many studies show that the identification of effective teacher behaviour or attitude is linked to teacher training or evaluation (Teddlie & Stringfield, 1993; Kyriakides et al., 2002; Lee et al., 2003; Teddlie, Stringfield & Burdett, 2003; Kyriakides, Demetriou & Charalambous, 2006). In terms of TER, effective teaching isolated from the effect the school has on student performance, can be avoided when teacher evaluation is based on the theoretical models (Kyriakides, Demetriou & Charalambous, 2006). Kyriakides et al. (2002) proposed school-based self-evaluation of teachers to overcome the traditionally limited conceptions of teaching and disconnection from teachers' professional development. At that stage, the criteria of effective teacher or teaching generated by researchers had not been linked to professional development. They argue that teachers' involvement in formulating the criteria for an effective teacher or teaching can induce teachers' commitment to professional development and eventually improve teaching and learning. The criteria identified in their study are in line with the previous research findings.

3.2.4 SCHOOL EFFECTIVENESS RESEARCH IN DEVELOPING COUNTRIES

Most SER was conducted in developed countries such as the USA, the Netherlands, the UK, and Australia, in mathematics or language, although a few studies were undertaken in developing countries (Scheerens & Bosker, 1997). Research shows that schools and teachers have a more significant effect on student learning in developing than developed countries (Heyneman & Loxley, 1983; Fuller, 1987; Fuller & Clarke, 1994). A study of van der Werf et al. (2001) conducted in Indonesia confirmed that factors at the classroom level are also relevant in developing countries, particularly the importance of quality of instruction to improve the quality of education. In a study conducted in China (Peng et al., 2006), the findings were that factors other than competitive educational aspiration or educational policy should be considered, as pointed out by Scheerens (2001). Inconsistency across subjects was also shown up by this study, and it was suggested that developing countries, where differences in educational conditions or outcomes are more numerous than in industrialized countries, should proactively focus planned changes and retroactively select indicators for the purpose of evaluation and monitoring.

Scheerens (2001) states that there are considerable differences between schools in developing countries, whereas the effect of school is minimal in developed countries. Material and human resource factors have strong effects in the developing countries but are negligible in industrialized countries, as shown in the “Heyneman-Loxley effect” (Baker et al., 2002). It was evident that there were great differences between advantaged and disadvantaged schools in South Africa (Howie, 2002; Reddy, 2005b), but in Australia there was no significant difference between rural and urban areas in terms of resource availability (Webster & Fisher, 2000), and in Korea the availability of school resources for mathematics did not have a convincing effect on achievement across schools (O’Dwyer, 2005). Scheerens (2001) points out that the effect of instructional factors receiving empirical support in developed countries is not clear in developing countries, suggesting that cultural factors are most likely to influence the effectiveness of specific educational systems in international comparative studies. This is more likely the case in comparison to East Asian countries, with its Confucian heritage.

The points above are supported in international comparative studies. Secondary analyses on TIMSS have found explanations for the variance of achievements from a perspective of culture or environment along with instructional factors. For example, House (2002) assessed the relationship between instructional practices and mathematics achievement in Chinese Taipei, and reported that cooperative learning, which had been proved as an effective instruction strategy to improve student self-confidence and achievement in Western countries, seemed not to hold for Asian students. Papanastasiou (2002) using the TIMSS data, compared attitudinal and instructional variables which differentiated 4th-grade students in Cyprus, Hong Kong and the USA. The results indicated that the same results in different contexts could be as a result of different reasons. Leung (2001) contrasted Eastern Asian mathematics compared to Western mathematics by six dichotomies:

- content versus process
- rote learning versus meaningful learning
- studying hard versus pleasurable learning
- extrinsic versus intrinsic motivations
- whole class teaching versus individualized learning
- subject versus pedagogy with respect to competence of teachers.

In spite of higher performance shown in TIMSS, Asian students' low confidence in subjects can be attributed to Confucian culture that emphasizes modesty (Leung, 2002). Shen (2005), conducting a comparison of the US middle school system with the five high-performing Asian school systems in TIMSS, found that American schools were less valued than Asian schools by parents and students and had a relatively shorter school year, higher student body mobility, more absenteeism, and frequent class interruptions.

Such differences between developed and developing countries appeared in tracking or grouping issues as well as cultural aspects. O'Dwyer (2005) explored the relationships between the learning environments in mathematics in 23 countries from the TIMSS data. Where education systems were not being tracked, variance of achievement occurred within classrooms, unlike schools where education systems were tracked. Specifically, students in Korea were shown to be taught in the most heterogeneous classrooms, which means no tracking. For South Africa, the most homogeneous classrooms were seen in 1995, but in 1999 classrooms had more heterogeneous groups, reflecting the large shifts in the education system since 1994. Based on this finding, it could be expected that achievement in Korea was accounted for by student-level factors, whereas South African students could be more influenced by school-level factors that the current study attempts to answer.

Taking into consideration Scheerens' arguments on cultural factors and the findings from TIMSS, the factors do not necessarily have the same influence on students in different contexts (Fuller & Clarke, 1994). Even though the outcomes or phenomena are similar in different contexts, factors underlying them could vary across countries (Bos & Kuiper, 1999; Papanastasiou, 2002; House, 2006). Furthermore, the comparison of educational systems or the evaluation of effectiveness of educational systems in developing countries should make allowances for contextual factors (Fuller & Clarke, 1994; Scheerens, 1997; 2001; Harber & Muthukrishna, 2000; Reddy, 2005a). It is argued that contextual relevance and the ideological context should be taken into account when the effectiveness of schools is evaluated (Harber & Muthukrishna, 2000). In the case of South Africa, elements of peace and democracy, such as non-violence and non-racism can be related to effectiveness from a South African point of view. As proven by Howie (2002) who examined the relationship between language and mathematics achievement, language is an issue specific to South Africa. Tracking resulting from SES and race is another issue to be considered in South Africa (O'Dwyer, 2005; Reddy, 2005b). As for Korea, an examination-driven competitive education system and Confucian culture should be considered, as in other Eastern Asian countries. As shown in Reynolds et al.'s (2002) comparative study concerning nine countries, the distinctions in school effectiveness vary across the cultures or SES, as well as across the countries. Therefore, it is plausible that schools with different contexts work differently to be effective in terms of outcomes (Teddlie & Stringfield, 1993; Reynolds et al., 2002) and educational effectiveness should be evaluated by multiple criteria, not by a single achievement test (Reynolds & Teddlie, 2000).

3.2.5 SCHOOL EFFECTIVENESS RESEARCH BASED ON SCIENCE

As mentioned above, SER focused on mathematics and language as independent variables (Scheerens et al., 2000) and consequently the findings are limited to the specific subjects. The notion that school effectiveness is subject-specific has been noted (Comber & Keeves, 1973; Coleman, 1975; Brophy & Good, 1986; Fuller & Clarke, 1994), while it was pointed out by Comber and Keeves (1973) that the effects in science could be different from other subjects such as reading, since science is more likely to be dependent on school instruction. Coleman (1975), who motivated SER, confirmed that schools had a larger impact on science rather than reading achievement of students in the secondary analysis of the IEA studies. As shown in the two consecutive studies of Kupermintz, Ennis, Hamilton, Talbert and Snow (1995), and Hamilton, Nussbaum, Kupermintz, Kerkhoven and Snow (1995), science was different from mathematics, as well as being very different from language or reading (Fuller, 1987). Their studies showed that mathematics, with its sequential-hierarchical structure of courses, was strongly affected by tracking and consequently only a few factors were shown to have an impact on achievement. In contrast, science with more likely heterogeneous content was less influenced by tracking and the effective factors vary across the content domains. From the comparison of TIMSS across participating countries, Grønmo, Kjærnsli and Lie (2004) found correlations in mathematics were much higher than in science, which means the patterns of science education across countries might be more heterogeneous, as in science content. Therefore, differential effectiveness across different subjects, or across different components, needs to be studied (Muijs et al., 2005).

Scheerens et al. (2000) also pointed out that empirical evidence needs to be supported across teachers, subjects, students, and schools. Leung, Yung and

Tso (2005) reported in the secondary analysis of Hong Kong science results in TIMSS 1999 that effective teaching methods varied between able and less able students. Besides, classroom conditions and climates influenced subjects differently. The study showed that the classroom conditions and climates influenced science achievement to a lesser extent than mathematics. Furthermore, it was found that value-added school effect was larger in science than in mathematics or language, and in developing countries than in developed countries (Scheerens & Bosker, 1997). Nonetheless, studies of school effectiveness have been rarely conducted when related to science or within developing countries.

3.3 FACTORS RELATED TO SCIENCE ACHIEVEMENT

In this section, many factors such as extrinsic and intrinsic factors, which tend to influence student achievement in science, are explored through presenting evidence from previous studies. Extrinsic factors operate from outside and can be manipulated by policy or intervention, whereas intrinsic factors are inherent in nature and cannot be changed by intervention. Although they can be discussed separately, as shown in the section below, they are interlinked. Firstly, two main extrinsic factors, time on task and opportunity to learn, are identified in the literature review. Considering that both are fundamental in each educational level, as represented in the conceptual framework, the two factors are reviewed in particular across these educational levels (3.3.1 and 3.3.2). Following the cross-level review on time and opportunity to learn, effective factors at the student level are explored more specifically, including intrinsic factors such as aptitudes, attitudes, and social context (3.3.3). Next, the classroom/teacher-level factors are investigated (3.3.4) and the factors of the school level are finally defined (3.3.5). All of the factors reviewed in these sections constitute the conceptual framework built in Chapter 4.

3.3.1 TIME ON TASK

‘Time on task’ is time spent on the learning task by students and is also called ‘effective learning time’ (Scheerens & Bosker, 1997, p.125) or ‘academic learning time’ (Creemers, 1994, p.28). It should be distinguished from ‘opportunity to learn’, which Carroll (1963) formulated as ‘time allowed for learning’ in his model of school learning in terms of time dimension. Time on task can operate according to each education level, viz., student, classroom, and school level.

At the student level, time on task contains the *time spent on doing homework*, *private tutoring*, or *outside-school activities*. Research shows that time spent on homework influences student science achievement in secondary school (Fraser, 1989; Reynolds & Walberg, 1991; 1992; Cooper, Lindsay, Nye & Greathouse, 1998). It was found that whereas there was a positive relationship between time spent on homework or daily out-of-school study time and high science achievement from the results of TIMSS and IAEP (International Assessment of Educational Progress) in higher achieving countries like Korea, this was not the case for lower achieving countries like Slovenia (Šetinc, 1999). The results of TIMSS 2003 also showed that the time spent on doing science homework was not associated with higher achievement, suggesting that the lower-performing students might be assigned more homework to keep up academically (Martin, Mullis, Gonzalez & Chrostowski, 2004). It was even reported that frequent homework was associated with lower attainment in core school subjects like mathematics, English, and science in the primary school (Farrow, Tymms & Henderson, 1999). It is apparent that teachers use homework differently, depending on the grade, and thereby the relationship between homework and achievement varies across subjects and grades (Van Voorhis, 2003), as was the case in Fraser’s study (1989) where the effects of homework were found to be negative in primary schools and positive in secondary schools, increasing with grade. For homework to be an effective means to extending the curriculum beyond school, it is evident that homework should be offered to students with consideration of appropriateness, their grade, and aims. For example, Van Voorhis (2003) found that interactive homework led to family involvement in homework and improving student science achievements and attitudes in a secondary school. In contrast, out-of-school time, namely leisure time, was found to have a negative effect on student science achievement (Fraser, 1989). This implies that there is more time spent watching television and less on learning tasks at home.

At the classroom/teacher level, the determination of time for learning can be made by the *time spent on teaching* by teachers in classrooms. In the studies conducted by IEA, FISS and SISS, time given to science teaching was proved to be related to the average achievement level of a country (Comber & Keeves, 1973; Postlethwaite & Wiley, 1992). At the classroom level, *instructional time* is important to achievement. Fraser (1989) reported that instructional time indexed by the total number of semesters of different science courses was a significant predictor of science achievement in the analysis of NAEP (National Assessment of Educational Progress) science assessment. Baker and Jones (2005) found in the secondary analyses of TIMSS and PISA that there is no consistent relationship between time spent on teaching science and science achievement internationally if one considers time allocated to science teaching; however, the frequency of interruptions to class showed a relationship with science achievement. This implies that actual time spent on teaching science influences student achievement. It was documented in TIMSS that in high performing countries, students tend to spend more time in their school and have more instructional time than in lower-performing countries (Martin, Mullis, Gonzalez, Smith & Kelly, 1999).

At the school level, time for learning involves the *time scheduled for science class,* such as *duration of class, school day per week or year* and the *frequency of field trips* as allocated by school policy. Rice (1999, p.223) reported that longer science classes in high school allow teachers more time to work with small groups of students using innovative instructional practices, and more time to discuss material as a group. Time on task, as engaged time in each learning process, is considered to be influenced by the perseverance of the student, the quality of the pedagogy, and opportunity to learn (Tate, 2001). It is evident that more time guarantees more student engagement with the learning task, though it does not mean more learning content, therefore, opportunity to learn should be taken into account along with time on task.

3.3.2 OPPORTUNITY TO LEARN

‘Opportunity to learn’ as opposed to learning time is mostly defined as content covered or curriculum alignment, and is measured in terms of the correspondence between learning tasks and the desired outcomes (Scheerens & Bosker, 1997). Opportunity to learn is concerned with what content is taught. The decision about what is taught, however, is made first at the context level by policy, which is called the intended curriculum in IEA studies (PIRLS and TIMSS). Following the decision made at this level, schools choose what should be taught, and teachers decide on the content to be implemented in the classroom. The review of opportunity to learn made here is explored from the higher educational level to the lower.

The intended curriculum is translated into rules or agreements about science instruction, such as *selecting a specific science textbook* and *arranging science courses* at each school. In the two studies conducted by IEA, FISS and SISS, opportunity to learn provided in the curriculum was shown to be related to the average achievement level of a country (Comber & Keeves, 1973; Postlethwaite & Wiley, 1992). In the re-analysis of the IEA studies involving reading, civics, and science, Coleman (1975) reported that science and civics are less influenced than reading by home background, which means science and civics could be more influenced by school factors. It is plausible that science knowledge differs from knowledge in such areas as reading and literature, and is more likely to be dependent on school instruction than on family factors (Comber & Keeves, 1973). This is the case especially in conditions of poverty, since schools could be the only resource that offers learners the opportunity to learn science (Reddy, 2005b). *Curriculum differentiation like tracking* or *course-taking opportunities* resulting in intra-school segregation, and thus producing differential learning opportunities, is another form of opportunity to learn (Hoffer, 1992; Spade, Columba & Vanfossen, 1997; Tate, 2001). It was also evidenced that, at the school level, course taking or course requirements can make a difference to the opportunity to learn (Hamilton et al., 1995), and the pattern of course offering and requirements showed a strong relationship with science achievement (Postlethwaite & Wiley, 1992).

Once science content to be taught is assigned at the school level, teachers make a final decision by implementation in the classroom, which is referred to as the implemented curriculum named in the IEA study. At the classroom level, the teacher can *emphasize specific content* that might be related to his/her major contribution to variance in opportunity to learn. Wang (1998b) found that *content exposure*, that is opportunity to learn, was the most significant predictor of student test scores, especially written test scores in Grade 8 science. Students make use of different opportunities to learn whether attending class or not. *Extracurricular activities like field trips* run by the school or out-of-school activities such as museum visits with parents also offer students opportunity to learn (Hamilton et al., 1995; Tate, 2001).

Opportunity to learn at the student level is mainly concerned with outside-of-school activities such as *private tutoring* and *doing homework*. *Visiting a zoo or museum, or participating in a science club* can also offer opportunities to learn (Griffin & Symington, 1997; Lindemann-Matthies & Kamer, 2006; Tran, 2007). It was found such activities as science museum visits can improve spatial-mechanical ability, which is seen to be instrumental in the variance within learning science (Hamilton et al., 1995). Additionally, *absenteeism* can negatively influence the opportunity to learn at the student level, considering that the school is the place where the main exposure to science knowledge occurs, especially in developing countries (de Feiter et al., 1995).

Opportunity to learn can be considered in terms of societal equity as well as education, because of a matter of access to content to learn. Researchers argued that opportunity to learn science is likely to be dependent on social contexts of the pupils such as SES, gender, and ethnicity as reviewed in Section 3.3.3.3 (Finn, Reis & Dulberg, 1980; Hamilton et al., 1995; Tate, 2001).

3.3.3 STUDENT BACKGROUND

This section explores student factors that are intrinsic in nature, and thus cannot be manipulated by policy as is the case with time on task or opportunity to learn. These intrinsic factors include student aptitude, attitude towards science, and SES. It should however be noted that attitude towards science is controversial in terms of manipulation’s point of view as reviewed in Section 3.3.3.2.

3.3.3.1 Aptitude

‘Aptitude’ is described in different ways by different authors. Sometimes known as prior knowledge (hereafter both terms are interchangeable), aptitude is what the student already knows, and has been identified as the single most important factor influencing achievement (Fraser, 1989; Lindemann-Matthies & Kamer, 2006).The ability to understand instruction depends on student aptitude (Creemers, 1994). It was proposed by Walberg (1990) that aptitude consists of three elements, viz., prior achievement, biological development, and motivation or self concept. Taken as a whole, these aptitudes are defined as prior knowledge measured by tests in the early learning stages of teaching and learning. Research has found that prior achievement has a greater impact on science achievement in secondary school (Reynolds, 1991; Reynolds & Walberg, 1991; 1992). In his study of the effects of the classroom assessment environment on mathematics and science achievement, Brookhart (1997) found that prior science achievement and general reading ability had the greatest impact on science achievement. Howie (2002) found a strong relationship between mathematics achievement and English proficiency in South African students and suggested that language factors could be a substitute for student aptitudes in this context. This relationship could also hold for science, given that the results of the later study with respect to science in South Africa did not differ much from those of mathematics (Howie et al., 2008).

3.3.3.2 Attitude

Research shows a relationship between attitude and achievement. The concept of attitude can be defined as a tendency or propensity to react to things and ideas (Simpson, Koballa, Oliver & Crawley, 1994), and favourable or unfavourable feelings toward a specific object (Papanastasiou, 2000). Since attitude contains the components of affect, cognition, and behaviour, it covers values, beliefs, and motivation. Attitude, either positive or negative, is proposed as one of the outcomes to be gained (Carey & Shavelson, 1989; Reynolds & Walberg, 1992) and therefore attitude towards science can be operationalized in many different ways among researchers, including *science self-concept, the degree of enjoying science,* and *perception of the value of science* as in TIMSS.

Since Bloom (1976) reported that 25% of the variance in school achievement could be accounted for by attitudes, including affective characteristics and subject-related self-concept (p.104), research has consistently - if not as much as Bloom predicted - shown that in science education, students' attitudes influence achievement (Freedman, 1997; Papanastasiou & Papanastasiou, 2004; Park & Park, 2006), or achievement influences attitudes (Reynolds & Walberg, 1992). More recently, relationships between attitudes and achievement in science have shown a reciprocal effect overall, although the examination by gender indicated a slightly different trend (Mattern & Schau, 2002). It was confirmed this reciprocal effect exists between attitudes and reading achievement (Williams, Williams, Kastberg & Jocelyn, 2005).

Regardless of the causal relationship between science attitudes and achievement, certain research found a correlation between attitudes and achievement (Kahle, Meece & Scantlebury, 2000; Shen & Pedulla, 2000; Papanastasiou & Zembylas, 2004; Chang & Cheng, 2008; Howie et al., 2008; Shen & Tam, 2008). Shen and Tam's (2008) cross-national examination of the TIMSS data, collected in 1995, 1999, and 2003 respectively, found that for within-country data there is a positive correlation between student achievement scores in science and mathematics. However, in a between-country analysis, the relationship is negative and these findings are consistent for both mathematics and science across the data for all three administrations, a finding which Wilkins (2004) confirmed. Papanastasiou and Zembylas (2004) examined a cross-cultural context using data from TIMSS and discussed differences in the attitude-achievement relationship in science in Cyprus, Australia, and the USA. The findings show that relationships between attitudes and achievement and the direction of the relationships or the impacts vary across the countries. For instance, high achievement generally was a good predictor of attitudes towards science in Australia. This works in reverse in that positive attitudes towards science were a good predictor of achievement in Cyprus. In the USA, high achievement had a relationship with poor attitudes, unlike in Australia. Suffice it to say that there is not an absolute or permanent relationship between science achievement and attitudes, but rather it can vary across countries, in what Papanastasiou and Zembylas called "a spatial and temporal locality of the relationship" (2004, p.259).

Generally, there are some explanations for students' attitudes, both positive and negative, towards science. Lyons (2006) found that the transmissive pedagogy, decontextualized content, and unnecessary difficulty of school science cause students' negative attitudes and lead to an aversion of careers in the field of science. Assuming that students' motivational characteristics are strongly related to the preferred kinds of learning activities and styles of teaching, when they experience less preferable instructional approaches, such experience is likely to de-motivate them (Stark & Gray, 1999).

In particular, students' negative attitudes towards science, even with high achievement, have been attributed to burn-out from examination-driven hard work (Papanastasiou & Zembylas, 2004; Murphy, Ambusaidi & Beggs, 2006), or cultural aspects such as modesty, shown in East-Asian countries (Leung, 2002). It was argued by Shen and Tam (2008) that the low confidence of the high-achiever might be due to high academic standards and expectations at the context level. By the same token, the high confidence of the lower-achiever might result from low academic standards and the expectation of society. As pointed out by Papanastasiou (2002), even though Cyprian students showed positive attitudes towards science, their achievement in TIMSS was poor, perhaps attributable to teachers' lower expectations of them.

Another feature of attitudes towards science is the decline of positive attitudes towards science as the grades progress (Greenfield, 1996; Stark & Gray, 1999; Wilkins, 2004; Murphy et al., 2006). The higher the grade, the more difficult the content (Lyons, 2006), and such decline in attitude seems unavoidable. Student achievement and attitudes are influenced jointly by a number of factors rather than by a single dominant one (Henderson, Fisher & Fraser, 2000), and these attitudes are difficult to change (Reynolds & Walberg, 1992; Papanastasiou & Papanastasiou, 2004). However, the decline of positive attitudes might not be the case globally, as proved by an example of the Singapore TIMSS results, where students retain positive attitudes towards science while maintaining high academic standards and expectations (Aun, Riley, Atputhasamy & Subramaniam, 2006; Shen & Tam, 2008).

Research shows that the quality or the nature of science instruction strongly influences student attitudes toward science (Freedman, 1997; Lyons, 2006). For example, investigating the attitudes towards science amongst 8th-grade students in Australia, Canada, Cyprus, and Korea, using the TIMSS data, Papanastasiou and Papanastasiou (2004) found that the strongest direct influences on attitudes toward science are teaching factors. In particular, instructional strategies concerned with regular practical work, laboratory instruction, and hands-on activities have been found to positively improve the student attitudes toward science, and in turn their achievement (Dechsri, Jones & Heikkinen, 1997; Freedman, 1997). George and Kaplan (1998) found that hands-on learning in the classroom or extracurricular science activities outside the school have the strongest direct effect on science attitudes. Odom, Stoddard and LaNasa (2007) concluded that attitudes and achievement among students can be improved through frequent use of student-centred teaching methods and degraded through frequent use of teacher-centred methods, indicating that attitudes towards science depend on how it is taught.

3.3.3.3 The social context of the students

Students' social contexts, which may have an influence on both attitude and achievement, refer to the *socio-economic status (SES), ethnicity, language,* and *gender* of the student. These aspects are inextricably interwoven and thus were discussed individually, as well as together. In addition, *'peer environment'* can influence student achievement and was discussed lastly.

The *SES* of students is determined by their parents' occupation and educational level, and the factor can operate in many ways, such as *parent education level, parent occupation, family size, books in the home, parent involvement,* and *mother tongue*. The home background of the student related to SES is the strongest factor influencing student achievement (see Section 3.2), and many studies show that, all being equal, students from families with a high SES outperform in science those with a low SES (O'Brien, Martinez-Pons & Kopala, 1999; Von Secker, 2004; Howie et al., 2008). The IEA studies consistently show that students from homes with extensive educational resources and/or well-educated parents have higher achievement in science than those from less advantaged backgrounds (Comber & Keeves, 1973; Postlethwaite & Wiley, 1992; Beaton, Martin, Mullis, Gonzalez, Smith & Kelly, 1996; Martin et al., 2000; 2004). It was found that home computers and visits to science museums, considered as general SES advantages, were significantly related to spatial-mechanical reasoning, which is essential in science learning (Hamilton et al., 1995). In addition, Von Secker (2004) found that students' home environment, including parents' education and literacy levels, were more strongly related to their science achievement as they progressed through school. In particular, books in the home, as an indicator of the domestic academic environment, were found to be an important factor related to student achievement in mathematics, science, and reading in the PISA study (Marks, Cresswell & Ainley, 2006). Goldhaber and Brewer (2000) reported that family background variables explain a considerable amount of the variance in Grade 12 mathematics and science test scores, in particular a statistically significant positive impact on tests by the father's level of education.

As a socio-economic indicator, parental involvement has been considered another reflection of SES (Bracey, 1996). *Parents* or *family* can influence children's education, and in turn achievement, in various ways, such as encouraging them to work hard, providing materials needed for learning, taking them to museums, or involving them in a school programme (Papanastasiou & Papanastasiou, 2004). This parental effect based on SES has been reported as being greater in science and mathematics than in reading and writing domains (Ma, 2000). Reynolds and Walberg (1991) found that the home environment factor has shown a positive, although moderate, effect on Grade 8 students' science achievement. Their study reported that student attitudes were strongly influenced by the home environment indirectly in Grade 10 science (1992).

Family support, including families' expectations of school performance, verbal encouragement or interactions regarding schoolwork was found to have a positive effect on science achievement (Cornelius-White, Garza & Hoey, 2004). In particular, parental aspirations or their expectations for their children's education achievement have been found to have the strongest relationship with students' academic achievement, including that in science (Trivette & Anderson, 1995; Fan & Chen, 2001). In addition to effects on achievement, parental involvement was proved to have a strong and direct, as well as indirect, influence on science attitudes in the way of mediation through science activities and library or museum visits (George & Kaplan, 1998). The family can also improve student achievement through helping with homework (Van Voorhis, 2003; Xu & Corno, 2003). In the USA a positive association was reported between ethnic minority students whose parents encouraged study of advanced science and their science achievement (Smith & Hausafus, 1998).

Ethnicity gaps have been found in science achievement (Greenfield, 1996; Adigwe, 1997; O'Brien et al., 1999) and generally students from ethnic majority groups record higher achievement levels in science than those students from minor ethnicity groups (Hamilton et al, 1995; Adigwe, 1997; Klein, Jovanovic, Stecher, McCaffrey, Shavelson, Haertel, Solano-Flores & Comfort, 1997). In South Africa, there are different Black ethnic groups in schools, and the language of instruction is usually English[7]. These students are faced with being taught in a *language* different from the one spoken in the home, and this contributeds to underachievement (Rollnick, 2000; Dempster, 2006; Howie et al., 2008).

From a social constructivist perspective, *language* in the science class plays an important role because scientific meaning is constructed through the social practices of teachers and learners (Fox, 2001). Rollnick (2000) contended that because of the difference between everyday language and science terminology, learning science seems to necessitate the learning of a new language, even for

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[7] The use of English as the language of instruction is the advantage of the White English speaking minority, thus perpetuating racial inequalites.

first language speakers. Therefore, the second language learners face two challenges simultaneously, namely to study the language of teaching and learning itself, and to learn science in their classroom. In South Africa, where most students learn science in schools in a second or a third language, language proficiency is a strong factor influencing student science achievement (Howie et al., 2008).

Gender issues are not new in education with boys performing better than girls in science (Comber & Keeves, 1973; Husen, Fagerlind & Liljefors, 1974; Postlethwaite & Wiley, 1992; McCrum, 1994; Hedges & Nowell, 1995; Beller & Gafni, 1996; Lee & Burkam, 1996; Adigwe, 1997; Burkam, Lee & Smerdon, 1997; Wang & Staver, 1997; Erinosho, 1999; Martin, Mullis, Gonzalez & Chrostowski, 2004; Van Langen, Bosker & Dekkers, 2006). Girls have been found to lag behind in mathematics and science while outperforming boys in language (Hedges & Nowell, 1995; Mau, 1995; Van Langen et al., 2006). Gender gaps in science achievement are a concern and have been researched, since the gaps are substantially greater than for other school subjects (Hedges & Nowell, 1995; Beller & Gafni, 1996). In 29 out of 45 participating countries in TIMSS 2003, boys significantly outperformed girls in science (Martin, Mullis, Gonzalez & Chrostowski, 2004). Generally, the variances in boys have been found to be greater than those in girls in science (Hedges & Nowell, 1995).

Research has shown that gender differences in science achievement vary across content domains and girls fare better than boys in biology, while boys outperform girls in physics (Husen et al., 1974; Postlethwaite & Wiley, 1992; McCrum, 1994; Beller & Gafni, 1996; Lee & Burkam, 1996; Burkam et al., 1997; Erinosho, 1999; Martin, Mullis, Gonzalez & Chrostowski, 2004). Gender differences were found in specific cognitive domains, such as spatial-mechanical ability, where boys perform better than girls (Hamilton et al., 1995). As TIMSS 1995, 1999, and 2003 show, males consistently outperformed girls in physics and earth science (Beaton et al., 1996; Martin et al., 2000; 2004), evidence that the gender variance in science achievement tends to persist and increase as the student progresses through school, regardless of whether girls have positive or negative attitudes towards science (Husen et al., 1974; Postlethwaite & Wiley, 1992; Burkam et al., 1997; Klein et al., 1997; Von Secker, 2004). Ultimately, this variance leads to a reduction of women's participation in science-related careers (Burkam et al., 1997; Erinosho, 1999; Gillibrand, 1999; Van Langen et al., 2006).

Gender gaps in science achievement were commonly explained in connection with differences in opportunity to learn, which results from differentiated educational systems, course-selection, and out-of-school science experiences. Gender gaps in science achievement appeared even among students within the same curriculum (Beller & Gafni, 1996). Students' prior science-related experiences and differential opportunity to learn, compounded by participation, cultural and social expectations, could increase gender gaps in science performance (Burkam et al., 1997). For example, it has been found that parental separation brings on an earlier-than-usual beginning of the female disadvantage in science achievement (Smith, 1992). There is a finding that the attitudes and expectations of male and female teachers are, like those of parents, greatly influenced by the traditional sex stereotyping of roles (Haussler & Hoffmann, 2002). Girls in single-sex classrooms or schools had more favourable attitudes towards science than those in mixed classrooms or schools (Dhindsa & Chung, 2003). Gillibrand (1999) found that girls who elected to study physics in a single sex class gained confidence in physics, and this was associated with better achievement. By contrast, Haussler and Hoffmann (2002) found that dividing classes according to gender has no effect on achievement, apart from improved interest in physics.

Not limited to educational factors, gender gaps in opportunity to learn science may emerge in various ways. The differences in socialization according to different social status, ethnicity, and SES may cause differentiated experiences of and interest in science (Klein et al., 1997; Jayaratne, Thomas & Trautmann, 2003). It therefore was pointed out achievement gaps in SES and ethnicity tend to be paralleled by gender gaps (Von Secker, 2004). For instance, Hamilton et al. (1995) found that the Black and Hispanic students in the USA had similar trends as girls fared better than boys in reading, but worse in spatial-mechanical reasoning. Adigwe (1997) also reported that there were significant differences in science test performance between ethnic groups as well as gender in Nigeria. Kahle et al. (2000) found in the analysis of urban African-American students that girls with more home support tended to have friends with science-oriented activities.

Some research attributed gender differences in science achievement to test format. The multiple-choice format has been found to favour males who are more willing to take this risk (Hamilton et al., 1995), while the open-ended format contributes to relatively higher performance among females (Bolger & Kellaghan, 1990). This could be attributable to the open-ended format being subject to language proficiency, in which girls tend to be stronger than boys (Van Langen et al., 2006). Hamilton (1998) found that boys outperformed girls on test items with visualization requirements and those which involved experience beyond school. Klein et al. (1997) found that girls scored slightly higher than boys on the performance assessments. These findings led to using performance assessment along with multiple-choice items, as tried in TIMSS (Kind, 1999).

Many interventions have been introduced to improve girls' attitudes towards science as gender differences in achievement tend to be mediated by parallel differences in attitudes, interests, perceived values, and self-concept (Williams et al., 2005). Instructional changes, including the adoption of regular hands-on activities, have improved girls' interest in science and reduced the gender gap (Lee & Burkam, 1996; Burkam et al., 1997). It was proposed by Van Langen, Bosker and Dekkers (2006) that integrated and comprehensive curricula and educational systems can reduce the gender gap, assuming that self-confidence for girls in differentiated versus integrated educational systems is associated with some sort of self-fulfilling prophecy mechanism and their achievement. As seen in the series of IEA studies, there have been declines in gender differences consistent with shifting educational opportunities, social roles, and the demands of the workplace (Linn & Hyde, 1989).

Lastly, *peer group* can influence student achievement. Walberg regarded peer environment as one of the important factors influencing student educational productivity (1990). The peer group was shown to influence student science achievement indirectly, mediated by instructional quality and instructional time (Reynolds & Walberg, 1991). It was documented that there was a positive correlation between peer support and academic achievement (Ashwin, 2003).

3.3.4 CLASSROOM-LEVEL FACTORS

Factors at classroom level also influence student outcomes, particularly in developing countries, where teacher and school factors prove to have a deeper effect on student science achievement than in developed countries (Heyneman & Loxley, 1983). The classroom level involves the science curriculum, the science teacher, the classroom climate, as well as the physical resources. In order for teaching and learning to take place in classrooms in practice, a science curriculum for teaching and learning should be in place with materials to support that teaching and learning. As they work together, such compositions induce unique climates in classrooms. As Creemers (1994) stated, factors identified here are important in any attempt to create an optimal composition and to enhance effectiveness, particularly if the classroom effect is higher than that of the individual factors.

3.3.4.1 Science curriculum

TIMSS conceptualizes the intended curriculum at the national level, the implemented curriculum at the teacher level, and the attained curriculum at the student level (Mullis et al., 2003). The science curriculum is mostly defined at the context level in the form of ministerial directives, instructional guides, school inspections, and recommended textbooks. At the school level, the science curriculum is considered in terms of curriculum management, as shown in Section 3.3.5.1. At the classroom level, the science curriculum is translated into science content, which is then taught using the recommended textbooks and workbooks in classroom. Therefore, the science curriculum reviewed here can be regarded as implemented curriculum at the classroom level.

When science teaching and learning take place in a classroom, a science teacher and his/her students have a science textbook or workbook as recommended at the country level according to the intended curriculum. A textbook not only represents an educational standard but also reflects comparative focuses of each educational system depending on distribution of space to different content and skills (Valverde & Schmidt, 2000). In science and mathematics textbook comparison in the USA and 21 high-achieving countries in TIMSS, it was found that coherence, focus, and level of curriculum were deficient in the USA, unlike the higher-achieving countries (Valverde & Schmidt, 2000). Most teachers use a textbook as the primary basis or a supplementary resource for their lessons (Martin, Mullis, Gonzalez & Chrostowski, 2004), implying that it helps them make decisions on the implemented curriculum, viz., opportunity to learn at the classroom. Therefore, the science textbook used in the classroom can be an important factor influencing student learning.

3.3.4.2 Teacher background

Science teacher quality examined here is divided into two aspects, including ‘teacher background’ and ‘teaching practice’. The role of the teacher in teaching and learning is important in implementing the intended curriculum. Teacher quality, depending on background and teaching practice, might be vital, given that many concepts in science are counterintuitive and difficult to understand even for adults, and under-qualified teachers may teach incorrect content or fail to correct their students' distorted understandings (Brophy & Good, 1986). Freedman (1997) argues that the quality of science education is correlated with the quality of instruction, which in turn is determined by teacher quality, and so affects student achievement (Darling-Hammond & Hudson, 1989). It is argued that the quality of teaching is also an important determinant of students' attitude towards science (Osborne, Simon, and Collins, 2003).

Mayer et al. (2000) identified four teacher characteristics as one part of school quality indicators, including *teacher academic skills, teacher experience, teaching assignment,* and *professional development,* and this is reinforced by Greenwald, Hedges and Laine (1996), who argued in meta-analysis that teacher quality, including *teacher ability, teacher education,* and *teacher experience,* was very strongly associated with student achievement. These aspects are inter-related but need to be discussed individually, as well as together.

Academic skill refers to teacher competence in terms of academic learning and is vital since it can influence subject matter knowledge and pedagogical skill. As seen in the majority of countries participating in the studies by IEA, FISS and SISS, students of teachers who were *experienced and competent* in science performed better (Comber & Keeves, 1973; Postlethwaite & Wiley, 1992). Similarly, Ehrenberg and Brewer (1994) found that the higher the quality of the institution a teacher attended, the more his or her students tended to learn.

As far as the teaching assignment is concerned, when teachers who lack subject matter knowledge teach the subject, they not only convey inaccurate content, but also fail to identify and remedy their students' misconceptions (Brophy & Good, 1986). Jita (1998) found that many science teachers in South Africa were deployed in other subjects as well as in science, and argues that teaching two or three different areas, including science, that demands more professional knowledge, might lead to teachers not being able to devote sufficient time to prepare adequately for effective teaching practice. According to Ingersoll (1999), this out-of-field teaching is likely to result in substandard teaching, and when conducted by a teacher without a strong background it might contribute to low science achievement at the Grade 12 level. Regardless of student achievement, it leads to boring teaching practice relying on textbooks, and failing to promote students' interest in the subject or development their critical-thinking ability. In addition, Ruby (2000) found that many teachers certified as K-6 teachers in the USA were often compelled to teach in middle schools, resulting in a lack of confidence in teaching science and a reduction in the intended content, especially in physical science which is considered difficult.

Teacher experience is significant in the light of teacher pedagogical content knowledge, related by Shulman (1986) to the teaching of subject matter knowledge and to be gained by means of the teaching practice as well as research. It seems practical that experienced teachers can represent topics to make their students understand better than novice teachers. Nye, Konstantopoulos and Hedges (2004) found that students learn more from experienced teachers than they do from inexperienced ones. A lack of science-teaching experience was pointed out as one of the challenges to reform of science education, particularly as more than 45 percent of general science teachers had fewer than two years' teaching experience in South Africa (Howie, 1999). In addition, TIMSS 2003 showed that the percentage (75%) of science teachers under 39 teaching Grade 8 in South Africa was higher than international average (50%) (Martin, Mullis, Gonzalez & Chrostowski, 2004). It was documented that the effects of teaching experience are curvilinear and teachers with five-to-ten years of experience have a more positive impact on achievement (Darling-Hammond, 2000; Nye, Konstantopoulos & Hedges, 2004).

Professional development, or "the process whereby teachers' professionality and/or professionalism may be considered to be enhanced" (Evans, 2002, p.131), is planned and offered by policymakers and educational reformers respectively to improve and develop teacher knowledge, skills, and practice, and thus improve student achievement. It is considered the best way to improve teaching practice, although teachers consider this an unfavourable learning source (Supovitz & Turner, 2000). In contrast to the initial intention, professional development programmes ultimately fail to change teachers' attitudes or teaching practices (Roehrig, Kruse & Kern, 2007) and short-term and event-like programmes might be regarded as contributing to such failure. In contrast, evidence shows that high quality professional development, consistently provided, improves science teachers' instruction (Kahle et al., 2000; Supovitz & Turner, 2000; Desimone, Porter, Garet, Yoon & Birman, 2002). Highly intensive, inquiry-based professional development in science and mathematics might change teachers' attitudes towards reform, their preparation, and teaching practices (Supovitz, Mayer & Kahle, 2000). Therefore, professional development which effects changes in teaching practice and classroom culture can in turn improve student achievement.

Teacher education is vital for developing subject matter and pedagogical knowledge as well as methodology prior to beginning a career. Based on a premise that the implemented curriculum may vary depending upon teachers' subject-matter knowledge and pedagogical knowledge, *teacher preparation of content* was argued to have a significant impact on teaching practice and classroom culture (Turner-Bisset, 1999; Supovitz & Turner, 2000; Darling-Hammond, 2007). Such subject-matter and pedagogical knowledge can be acquired through *pre-service education*, namely *major in undergraduate school including degree* and *certification*, and *in-service education*, namely professional development. However, the type of pre-service education is important in determining the quality of teacher training.

With respect to the relationship between teachers' formal qualifications and student achievement, it was found that the relationship between the formal education of the teacher and student results is generally weak in the West, yet this is stronger for science and mathematics than for other subjects (Brophy &

Good, 1986). Research shows that students taught by teachers holding a science degree or certification in science teaching, outperformed those with teachers who were not science-trained (Druva & Anderson, 1983; Monk, 1994). Monk (1994) found that high school students’ science test scores have a bearing on the subject-matter preparation of their teachers, although to a lesser extent in mathematics. Goldhaber and Brewer’s study (2000) contradict this, as they found no significant effect on student achievement in mathematics and science in terms of teacher certification and degree. However, this evidence should be interpreted with care, considering that most US college students selecting education majors tend to be drawn from the lower part of the ability quotient. Nonetheless, the studies also reported that subject matter preparation by means of a higher degree and certification has an effect on student achievement even after controlling for variables such as ethnicity and SES in science, albeit to a lesser extent than in mathematics (Goldhaber & Brewer, 2000).

In addition to these factors, teacher background includes *gender*. Although it was believed that there is no impact from teachers’ gender difference on student science achievement (Brophy, 1985), it was found that 15% of the variation in students' science achievement scores was due to teacher differences, and one of the two teacher factors was gender (Kahle et al., 2000). There was a higher level of science achievement in female teachers' classes in their study, with female teachers more likely to take responsibility for their students' learning than male teachers (Curtis, 1999).

3.3.4.3 Teaching practice

Effective teaching practice is a core of instructional quality along with teacher background in science, given that it can directly influence student achievement (Brophy & Good, 1986; Johnson, Kahle & Fargo, 2007). The main effects of instruction on mean science achievement of a school was analyzed by Von Secker and Lissitz (1999) and they found that instructional practices affect individual science achievement interacting with gender, minority status, and SES. Some factors with respect to instructional quality were identified in SER. Scheerens and Bosker (1997) proposed structured instruction, including structure and preparation of lessons, direct instruction, and monitoring. Creemers (1994) reported the more detailed factors under three components, teacher behaviour, grouping, and curriculum, to be explored further in Chapter 4. Wise and Okey (1983) examined the effects of various categories of teaching strategies on achievement in science in primary through high schools, and identified 12 categories of teaching techniques: “Audio-visual, Focusing, Grading, Inquiry, Manipulative, Modified, Presentation approach, Questioning, Teacher direction, Testing, Wait-time, and Miscellaneous” (p. 420).

Thereafter, Wise (1996) reported the results of a secondary meta-analysis of 140 studies comparing the effects of traditional science teaching strategies with those of alternative strategies on student science achievement at middle and secondary schools. Consequently, the 12 alternative science teaching strategies identified previously were reduced into eight categories considering usefulness: “Questioning, Focusing, Manipulation, Enhanced Materials, Testing, Inquiry, Enhanced Context, and Instructional Media” (p.337).

Recently, Schroeder, Scott, Tolson, Huang, and Lee (2007), examining the extant body of recent studies in science teaching to provide research-based evidence of effective teaching strategies, suggested ten strategies modified and employed on the basis of the Wise’s eight teaching strategy categories: “Questioning, Focusing, Manipulation, Enhanced material, Assessment, Inquiry, Enhanced context, Instructional technology, Direct instruction strategy, and Collaborative learning strategy” (pp.1445-1446). Two strategies, namely direct instruction and collaborative learning were added to the original set to reflect more recent emphasis. Two other strategies, viz., assessment and instructional technology strategy, were renamed to broadly cover the related elements. In what follows, additional research evidence is presented in an expository way along with the definitions made in the study above.

Questioning strategies are concerned with the timing and positioning of questions used by teachers and include the use of wait-time or pause at a key point. This strategy was found to have the strongest effect on student achievement in Wise's study (1996). It should be borne in mind that questioning strategies are inextricably linked with 'focusing' and 'assessment' strategies explored below. 'Teacher questioning' has evolved to interaction and the discourse taking place in the science classroom as constructivist approaches become prevalent. From a perspective of social constructivism, questioning in the science class can be adopted to clarify meanings, examine a variety of views, and finally construct scientific knowledge by means of using language. Van Zee and Minstrell (1997a) proposed the so-called ''reflective toss'' strategy, which includes a student statement, teacher question, and additional student statements to promote the responsibility for thinking in the discourse. The authors (1997b) state that the more open questions the teachers ask, and the more they acknowledge student contributions, the more students tend to engage in taking responsibility for thinking in the classroom discourse. In analyzing classroom talk and interaction in the science class, Chin (2007) stated that discourse based on questioning can help students scaffold their thinking and construct scientific conceptions.

Focusing strategies provide or reinforce objectives or use advanced organizers during the middle sections or at the closing of a class, to strong effect. As indicated above, focusing (or 'emphasizing') strategies can be examined in terms of the interactive context between a teacher and his or her students. In the examination of classroom interaction and discourse, Chin (2007) found that focusing strategies encourage students to develop productive-thinking abilities and thereby promote multi-faceted views. Her other finding showed that when teachers offer students a question-based summary, it helps them strengthen the key points of the lesson. She argued that using such strategies appropriately can serve to reinforce basic skills that students should learn, so that they can apply the basic knowledge to solve more complex problems later. It is therefore evident that focusing strategies assist in the learning of basic and existing knowledge in science.

Manipulation strategies involve students in physical activities such as operating apparatus through practical work, and permeate most laboratory activities. There is evidence that students who had regular laboratory instruction scored significantly higher achievement ratings in science knowledge than those who had no laboratory experience (Freedman, 1997). It was confirmed in documentation by Von Secker and Lissitz (1999) that instruction emphasizing laboratory inquiry was invariably associated with higher achievement. Odom et al. (2007) reported that near-daily implementation of group experiments, giving reasons for answers, solving problems, providing information to support answers, and learning from classmates, have a positive association with student achievement. Practical work was also proven to increase students' positive attitudes towards science (George & Kaplan, 1998), as well as their achievement This positive effect might be attributable to the fact that practical work makes learning science meaningful (Hattingh et al., 2007).

In particular, Burkam, Lee and Smerdon, (1997) found that practical work favoured girls and students from minorities or of low SES. Despite such positive effects of practical work, there is a reverse finding as well. For example, in science classes the time spent on laboratory and equipment per se was not related to learning. This suggests that students' active involvement in laboratory work is more important than the quantity of lab work or quality of the equipment. Different aims for practical work depending on different contexts may lead to such inconsistent results (Swain, Monk & Johnson, 1999). In addition, strict rather than helpful teacher behaviour was found to correlate negatively with practical test performance (Henderson et al., 2000). Some social constructivists argue that practical work in school science should be used as open-ended investigation intended to develop problem-solving rather than a pedagogical means of science learning (Kind, 1999).

Enhanced material strategies are those in which the teacher modifies instructional materials to make them more suitable to student needs or status. Leung et al. (2005) found that effective teaching methods on less able students were different from those used with able students, contending that teachers should adjust their instructional methods according to student need. SER lends support to this point, and Muijs et al. (2005) argue that teaching strategies should be different according to students' ability and SES. There is evidence that effective teachers adjust their teaching to fit the needs of different students and the demands of different instructional goals, topics, and methods (Darling-Hammond, 2000).

Assessment strategies include diagnostic and formative testing, immediate or explanatory feedback, and testing to mastery. Bloom (1974) named the whole procedure of the original teaching practice, the feedback, and the correctives as the quality of instruction under the mastery of learning conditions. Where the quality of instruction is high, student achievement and time on task in the classroom improve, and vice versa, with formative assessment improving student learning (Black & Wiliam, 1998). In a study into the effects of the classroom assessment environment on mathematics and science achievement, Brookhart (1997) found that the frequency of oral reports, written reports, and science projects were more important to science achievement than to mathematics achievement. Oral reports, which may be time-consuming, had negative effects, while science projects had positive effects, and written reports showed mixed effects. Black and Wiliam (1998), in examining classroom formative assessment, provided evidence that well-designed questioning, tests, and feedback in science classroom improve student learning. Chin (2006) studied classroom interaction in science and identified the various forms of feedback presented by science teachers. The feedback classified in the study was categorized into four forms:

“Affirmation-Direct Instruction, Focusing and Zooming, Explicit Correction–Direct Instruction, and Constructive Challenge” (p.1326). The author found that, in particular, ‘Focusing and Zooming’ and ‘Constructive Challenge’ feedback types prompted students’ responses, encouraged generative thinking, and improved the conceptual knowledge of students.

Inquiry strategies are student-centred and relate to discovery instruction. Inquiry-based instruction covers facilitated inquiry, guided discoveries, inductive laboratories, and indirect instruction. Whereas teacher-centred strategy involves whole-class instruction, recitation, and limited independent practice, student-centred strategy has to do with active student engagement, interactive scientific inquiry, and lifelong learning. In particular, emphasis on laboratory inquiry at the school level has shown a positive relationship with science achievement (Von Secker & Lissitz, 1999). It was found that emphasis on problem-solving and understanding among the instructional factors was associated with basic knowledge and reasoning in science (Hamilton et al., 1995). Active involvement in the science classroom has shown that the gender achievement gap can decrease due to improving gender equity (Burkam et al., 1997).

Chang (1999) reported that an instructional model based on problem-solving significantly improved the achievement of students in a Taiwanese ninth grade earth science class. Kahle et al. (2000) studied the influence of standards-based teaching practices, including inquiry, problem-solving, and open-ended questioning and detected a positive effect on science achievement in urban African-American students. Similarly, Gaigher, Rogan and Braun (2006) found that a structured problem-solving strategy in physics improved South African student achievement in this area. There is therefore significant evidence that collaborative laboratory work based on student-centred and active learning in the high school classroom can lead to enhanced content knowledge and process learning for their students (Taraban, Box, Myers, Pollard & Bowen, 2007).

Enhanced context strategies are related to field trips, group discussions, self-paced learning, problem-based learning, games, and simulations. Teachers can use organizational schemes or contexts differing from the ordinary to draw students' interest and engage them in learning. It was documented that student participation in extracurricular science activities such as science clubs and fairs have significant influence on their attitudes toward science (George & Kaplan, 1998). Griffin and Symington (1997) contended from the observation of a school excursion visit to a museum in Australia that field trips should be used as informal learning and are a valuable teaching strategy. The finding showed that students who have worked on a topic at school before visiting a museum, and who have prepared for their visit, learn most from their experience. Outside-school activities such as field trips were reported to offer students physical engagement experiences to foster learning (Lindemann-Matthies & Kamer, 2006). Many outside-school activities tend to be related to biology or earth science domains, in contrast to physics learning. However, Anderson and Nashon (2007) show the possibility of physics learning based on meta-cognition in organized school visits to informal contexts.

Instructional technology strategies include instruction based on audio and video materials, media, and such technology as computers. The effect of computer use in a science class was shown to be positive, but negative in mathematics in Korea (Park & Park, 2006). There is evidence that teacher-directed computer-assisted instruction can be an alternative in teaching basic science concepts in the secondary classroom. Chang's (2003) research of the comparative efficacy of computer-assisted instruction and traditional instruction on student science learning in a Taiwanese secondary school found that students experiencing teacher-directed computer assisted instruction had significantly higher score gains than those engaged in student-controlled computer-assisted instruction in earth science. It was documented that interventions, such as the use of computer-supported learning environments, strengthen the performance of able students, whereas less able students tend to show a poorer performance.

Information and communication technology (ICT) was shown to be an educational medium for a variety of learning tasks focusing on strengthening the knowledge base and thinking skills (Taconis, Ferguson-Hessler & Broekkamp, 2001). There is, however, a reverse finding that technology use has a negative effect on science achievement (Aypay, Erdoğan & Sözer, 2007). This finding was confirmed by Waight and Abd-El-Khalick (2007), wherein the use of computer technology hampered 'inquiry' in the sixth grade science classroom, contrary to expectation. They went on to contend that this result could be attributed to less time dedicated to group discourse, which is seen to lead to critical, meaning-making conversations. This could however be because computers in science are employed for the wrong reasons, such as a substitute for solid instruction and active investigation (Burkam et al., 1997).

Direct instruction newly added by Schroeder et al. (2007), involves teachers' verbal delivery of information or explicit guides for students, for example in designing experiments, using a microscope and making measurements. Direct instruction is more likely to meet teacher-centred traditional strategies, while teacher-led direct instruction was proved to be more effective than individualized instruction (Brophy & Good, 1986). Examination of classroom interactions related to difference in students' science achievement by Zady, Porters and Dan Ochs (2003), it was confirmed by Walberg (1991) that direct teacher instruction was more prevalent with high achievers than low achievers. The many children who learned about experimental design from direct instruction learned more and performed as well as those few children who found their own way in the third and fourth grade (Klahr & Nigam, 2004). This, however, was not confirmed in the longer term framework, as Dean Jr. and Kuhn (2007) found that only when direct instruction was coalesced with regular practice, was the effect strong. Finally, Fradd and Lee (1999) contended that learners with more authoritarian cultures may benefit from a more directly explicit approach regarded as traditionally teacher-centred.

Collaborative learning strategies, reflecting the recent emphasis on grouping learning in science, arrange students in flexible groups to work on various tasks. In reality, laboratory activities, inquiry projects, or discussions, are mostly practiced in groups. Harskamp and Ding (2006) studied the effects of structured collaborative learning and individual learning in the physics class of a secondary school in Shanghai, concluding that students who learnt to solve problems in collaboration, and those who learnt to solve problems individually with information or hints, were more likely to improve their problem-solving skills than those who learnt to solve the problems individually, without hints. Group-working students tend to solve problems in a less organized way, and as Odom et al., (2007) found, groups working with student-centred strategies learn from peer interaction, and thus improve their achievement.

It should be borne in mind that each alternative strategy examined above does not run alone, but becomes integrated as effective teaching is a product of various mixed strategies employed by the teacher (Muijs & Reynolds, 2000). For instance, practical work, based on an inquiry strategy, may take place in groups, and there is evidence that successful teachers are more likely to use various teaching strategies than a single approach, considering objectives to be taught and student needs (Hanushek, 1971; Doyle, 1985). This point is supported by Taconis, Ferguson-Hessler and Broekkamp (2001), who found that while problem-solving strategies provide the learners with guidelines, criteria, and immediate feedback that improved problem-solving skills, group work without such variables did not lead to positive effects. After enumerating all these effective teaching strategies, Wise (1996) reinforced an inquiry-oriented strategy as a common feature underlying all these alternative strategies relative to traditional strategies, and suggested that teachers should take inquiry strategies as the principal approach in science instruction.

Whatever strategy is used, there is an emphasis on the importance of students' active engagement and connection with everyday life, reflecting a constant emphasis on engagement in science along with constructivism (Floden, 2001). Such findings were confirmed in a project titled *School Innovation in Science in Australia*, which identified effective teaching practices in a science classroom from a perspective of teaching and learning (Tytler, 2003; Tytler et al., 2004). Drawing from the interviews with teachers, they identified eight effective components, summarized as students' active engagement with class, monitoring of and reflecting on students' needs and learning, and emphasis on linkage with daily life and the community. Students' active engagement and the emphasis on linkage with daily life represent constructivist strategies that have been proved to be influential in science teaching (Brophy, 1992). Odom et al. (2007) support this point by stating that when the more engaged students are actively generating and testing hypotheses, there is greater understanding and a better attitude towards science.

3.3.4.4 Classroom climate

Classroom climate is the atmosphere developed in a dynamic relationship by teachers and students within their learning environments during the school year (Fraser, 1994). Such psychological environments as morale or climate of the classroom formed by a social group were considered important factors that influence student outcomes in a theory of educational productivity (Walberg, 1990). The empirical evidence was documented, as Haertel, Walberg and Haertel (1981) studied the secondary analysis to find correlations between student perceptions of the social-psychological environments of their classes and learning outcomes in eight subject areas, including science. Their results indicated that student learning achievement had a positive association with *cohesiveness, satisfaction, task difficulty, formality, goal direction, democracy,* and *the material environment* and a negative relationship to *friction, cliquishness, apathy*, and *disorganization*.

The classroom climate for middle-grade students in secondary schools seems more important than for other grade students. The findings of Fraser (1989) in the study of analysis of NAEP science assessment reveal that classroom climate during science lessons was shown to have a stronger impact on the science achievement of 13 year-old students than on that of 17- and 9-year old students. There is evidence that classroom climate has influenced student science achievement indirectly, mediated by instructional quality and instructional time (Reynolds & Walberg, 1991). The learning atmosphere, resulting from the interactions between a teacher and students, was found to persist beyond their classrooms, such as in visiting museums (Tran, 2007). Therefore, it is evident that a favourable climate works not only within the classroom but also outside it, for student learning.

Desirable student outcomes could be expected to emerge from a stable climate in the classroom, but in order to create this the management behaviour of the teacher must come into play (Creemers, 1994). *Teacher attitudes* may be one factor to indirectly contribute to this classroom climate, since *teachers' beliefs, perceptions* or *interests towards science, teaching science,* or *their students* influence teaching practice or strategies (Jita, 2004; Hattingh et al., 2007; Roehrig et al., 2007), and in turn teaching practice influences students' attitudes towards science as examined above. SER also identified that classroom climate is enhanced by orderly-management (Creemers, 1994; Scheerens & Bosker, 1997). It was found that teacher's strong leadership and provision of a degree of student responsibility are more likely to promote achievement, whereas a greater degree of strict behaviour by the teacher and emphasis on rules (regulation on acting in laboratory) and clarity in science laboratories are negatively related to student achievement (Henderson et al., 2000). This occurs because the former results in a well-organized and responsible involvement of the students, whereas the latter makes them withdraw and not get into trouble.

Teachers' attitudes, *students' attitudes and behaviour,* based on their social contexts, can contribute to classroom climate. The finding that the classes of high performance schools showed fewer *intrusions* and *disruptions*, which leads to more instructional or learning time, is well documented in research (Creemers, 1994). When Dumay and Dupriez (2007) examined the TIMSS 2003 data, they found a significant part of the between-class variance in mathematics could be explained by class climate, particularly the joint effect of students' composition and such class processes as teaching practice. In the comparison of the USA and five top-performing Asian countries in TIMSS 1999, Shen (2005) found that there was more absenteeism and frequent class interruption in American schools than in the Asian schools, and American parents and students valued schooling less than their Asian counterparts. Therefore, students as well as teachers play a role in generating a favourable atmosphere to learning, and thus at the classroom level students can contribute to their own achievement.

3.3.4.5 Physical resources at a classroom level

Science depends on physical resources that assist in understanding scientific knowledge and developing skills through hands-on activities (Rogan, 2000). In addition, physical resources are important, given that enhanced material strategies and instructional technology strategies are regarded as effective science teaching practice as explored above. Science-specific physical resources include *laboratory equipment* and *materials for science experiments, science instructional materials, audio-visual facilities, computer software, availability of computers,* and *internet access for science teaching*. It was documented that science equipment had a positive effect on science achievement in eight countries participating in SISS (Postlethwaite & Wiley, 1992). Physical resources such as technologies or devices may help students objectify the observed world and appropriate learning tools can improve science instruction (Tate, 2001). Essentially, teachers can improve their instructional quality when provided with the appropriate classroom resources combined with professional learning opportunities and support (Tate, 2001). Available resources in schools, including instructional materials, time for teachers to plan and prepare lessons, and availability of relevant science supplies, were reported as having a statistically significant impact, in particular on teachers' investigative practices (Supovitz &Turner, 2000). Therefore, when implementing science curriculum reform, physical resources were regarded as an important factor, together with factors of teacher and student, school ethos and management (Rogan & Grayson, 2003; Rogan & Aldous, 2005).

In particular, the availability of computers for teachers and students is becoming a vital resource in schools, reflecting the importance of preparation for a highly IT-centred society around the globe. It was documented that using such technology as computers fostered and encouraged students to engage in learning (Tal, Krajcik & Blumenfeld, 2006). However, there is a controversial issue about the effects of computer technology. As reviewed above, the way that technology is used in the classroom depends on teaching practice, hence, the availability of computers and access to the Internet should be considered from a perspective of educational resources in a different way from the one discussed in teaching strategies.

On the other hand, students from minorities, or of low SES, can benefit from practical work using instructional materials as mentioned above (Burkam et al., 1997). This could be attributable to limited access to various informal experiences and the material offered in the classroom being the only opportunity for them to experience science activities (de Feiter et al., 1995). It was found by Hattingh et al. (2007) that the less proficient the learners are in the instruction language, the higher the need for practical work. In particular, in countries such as South Africa, where many students study science in a language different from their mother tongue, teachers need to use practical work to compensate for poor verbal communication.

In contrast to the aforementioned benefits resulting from the presence of physical resources, it is argued that lack of such resources as science teaching facilities, laboratories and equipment, together with large class size, leads to students' view of science as memorization rather than problem-solving (Black, Atwaru-Okello, Kiwanuka, Serwadda, Birabi, Malinga, Biumigishu & Rodd, 1998). It was universally reported in TIMSS that shortages of resource and material had an adverse effect on science instruction (Mayer et al., 2000).

Class size was reported to having a significant impact on student learning in the classroom, although how many students should be in one classroom is manipulated by policy at the higher context level (Mayer et al., 2000). Considerable research has provided evidence that class size influences student achievement (Greenwald, Hedges & Laine, 1996; Blatchford, Russell, Bassett, Brown & Martin, 2007). Research shows that, in particular, younger, disadvantaged, and minority students learn better in smaller classes (Mosteller, 1995; Rice, 1999). From the secondary analysis of the National Education Longitudinal Study (NELS) of the US Department of Education data of Grade 8 students, Akerhielm (1995) reported that small class size had a positive influence on student achievement in certain subjects, including science.

It was reported that both students and teachers benefit from small class size (Blatchford & Mortimore, 1994; Blatchford et al., 2007), while Rice (1999) confirmed the above findings in a study examining the impact of class size on instructional practices, and the use of time in high school mathematics and science. From the perspective of students, it is easy to focus on and spend more time on the learning task, as more attention and teaching from the teacher encourages them to develop good attitudes towards their learning. As a consequence, small classes tend to lead to higher levels of engagement, which in turn results in higher student achievement (Finn & Achilles, 1990; Blatchford et al., 2007).

Unlike small class size, large class size can cause non-instructional use of time, such as conducting administrative tasks and maintaining order in the classroom. Therefore, more time resulting from less interruption allows the teachers more opportunities to use teaching materials, leading to broader and deeper curriculum cover and improved student confidence, knowledge, and skills in science. However, one thing should be borne in mind in terms of the benefits of a small class, that only when accompanying a change of teaching practice and support of qualified teachers will the effect of small classes have a positive impact on student achievement (Mayer et al., 2000).

As opposed to the positive contribution of resources to teaching practices, there are some negative findings about the use of resources. The presence of resources does not guarantee use of them, as shown in the Stark and Gray study (1999) where the low use of computers in secondary science was reported by pupils despite the highest number of computers per school in the TIMSS report. Hattingh et al. (2007) examined practical work in the teaching of natural science in the light of curriculum implementation in South Africa, where an outcomes-based curriculum was being taught. In a related study, Rogan and Aldous (2005) found no relationship between availability of resources and the level of practical work. Nonetheless, ironically, the most commonly reported problems in the conduct of laboratory work were related to poor conditions, insufficient equipment and an extended preparation time (Wilkinson & Ward, 1997). It is a general belief that availability of science facilities has a significant and direct effect on science experiments and thus on student achievement (George & Kaplan, 1998).

3.3.5 SCHOOL-LEVEL FACTORS INFLUENCING SCIENCE EDUCATION

More attention has been given to factors at the school level which influence student achievement than to classroom-level factors, because school-level factors are only alterable by policy or financial investment, although various factors at the school level tend to be inter-related and difficult to quantify.

Accordingly, they are likely to indirectly influence student learning, and to mediate through teachers and classrooms (Mayer et al., 2000), whereas teacher or classroom level attributes influence student learning directly. Factors at the school level reviewed here are curriculum management, professional teaching force, school climate, and resources. Since the school unit encompasses other subjects as well as science, the review is likely to be general rather than science-specific.

3.3.5.1 Curriculum management

Curriculum management involves the way schools work on *curriculum-related tasks or decisions,* such as *choosing textbooks, determining course content, course offerings, student grading policies, assigning teachers to science classes,* and *instructional days or hours per year*. The curriculum taught in the school may vary depending on which kind of textbook is chosen and used, although the decision of the intended curriculum is made at the context level. The number of instructional days in the school year was reported as having a positive correlation with the national mean achievement in science as well as mathematics in TIMSS (Martin et al., 1999). Instructional days are inextricably linked to ‘time on task’ or ‘opportunity to learn’, considering that more instructional days a year may offer students more time in their school and thereby more instructional time. Therefore, the policy of the number of hours per year devoted to science directly influence the instructional time for science.

The number of hours per year allocated to science education influence the implemented curriculum, particularly if science is taught as integrated or separate units. It was found that students who were being taught science as separated disciplines had more instructional time than those who are taught science as an integrated subject (Martin, Mullis, Gonzalez & Chrostowski, 2004). The content taught in each grade can also influence student learning, therefore the decisions on course content and offerings are important. Two important reasons for US students' poor performance in international comparative studies like TIMSS have emerged: one is a 'cafeteria-style' and diffuse science and mathematics curriculum, which means a lack of content focus; the other is a variation in topic coverage across classrooms (Mayer et al., 2000; Valverde & Schmidt, 2000). This is especially evident in countries with a decentralized curriculum, as in the USA. At school level, it is important to appropriately and consistently choose and arrange science courses or content to ensure that teachers do follow a standards-based curriculum.

3.3.5.2 Professional teaching force

The professional teaching force involves *educational leadership, consensus or cohesion among school staff including teachers,* and a *stable body of teachers*. Educational leadership by principals was consistently reported to be an effective factor of achievement (Edmonds, 1979; Mulford, 1988; Scheerens & Bosker, 1997; Tate, 2001). Although the core role in the professional teaching force is thought to be played by a principal, in reality principals, according to TIMSS findings, tend to manage administrative duties rather than instructional leadership activities, such as overseeing curriculum planning, training teachers, and working with teachers to develop educational objectives (Martin et al., 1999).

However, this is not always the case for all schools, public or private. There is evidence that public schools are different from private schools in terms of the structure of their governance. In the school district administration common to public systems, teachers tend to regard their principals as lower-level managers, while in private schools the principals tend to take more responsibilities and play the role of a leader (Mayer et al., 2000).

In addition, principals influence teaching and learning in schools differently across countries. Reynolds et al. (2002) studied SER across nine countries in an attempt to determine which school and teacher factors were effective in different countries, which were universal, and which specific to certain countries. Their findings indicated that in English-speaking countries, including the USA, the UK, Ireland (Republic of Ireland), Australia, and Canada, school effectiveness depends more on the leadership of a principal, whereas non-English-speaking societies including Hong Kong, Taiwan, the Netherlands, and Norway have, according to Reynolds et al., such a well-ordered and well-engineered educational system that individual leadership and the relationships among the staff members are less important than system variables. A similar finding, reported above, indicates that the leadership factor shows a positive effect on student achievement in the USA but this is not the case in the Netherlands (Creemers, 1994). It is worthy of attention that Singapore, the highest-performing country in three sequential TIMSS administrations, showing no gender difference and no expense of affect in their science achievement, places emphasis on the CEO-like systemic commitment towards a good school organization through the special leaders-in-education programme for potential school principals (Aun et al., 2006).

Apart from principals, school staff and teachers mould a professional teaching force as well. For instance, *regular meeting of teachers* may be effective in improving cohesion and collaboration among teachers. Teachers, staff, and a principal working collectively within a school can have a positive effect on student learning. It was found that teachers valued collegial support and team planning, and the support was most effective when coordinated by a science administrator through frequent meetings focused on student learning (Roehrig et al., 2007). The professional teaching force is likely to establish common goals, to focus cohesively on student learning, be willing to collaborate and be open to new ideas, all directed toward high student achievement. Cohesion among staff and teachers in a school can be translated into consistency, and in turn develop a more favourable atmosphere, yet it should be noted that without appropriate professional development and supporting resources, a shared vision and cohesion alone does not guarantee the successful implementation of the intended curriculum (Singh & Manser, 2000).

It was suggested that an *experienced* and *stable community* of teachers is more likely to be professional (Hanushek, Kain & Rivkin, 1998). Jita (1998) found in the study of the context of science education in a South African rural area that 84.4% of respondents were under the age of 39, reflecting a lack of veteran and experienced teachers in the secondary science classroom. Unstable employment contributed to the unstable teacher community in this context and, in addition, the high rate of teacher attrition was reported to decrease teacher morale (Howie, 1999).

3.3.5.3 School climate

Research has shown that an *orderly school atmosphere* and a *positive disciplinary climate*, coupled with other attributes of school, teacher, and classroom, are conducive to student learning (Good & Brophy, 1986; Mulford, 1988). In addition, culture of school that is acceptable seems to support effective schooling, resulting in school improvement (Creemers, 2002). A study by Scherman (2005) into school climate in secondary schools of South Africa identified five factors which could distinguish the sampled schools in terms of school climate, viz., *Interaction, Cohesion, Learning environment, Resources, and Violence*. Certainly, students benefit from a school climate that minimizes discipline problems and clearly encourages academic excellence. School discipline related to school climate includes *student disrespect for teachers, absenteeism, tardiness, bullying, fighting,* and *theft*.

The TIMSS data also shows that the less absenteeism the more stable the student body, and the fewer problems the higher the achievement (Martin et al., 1999). It was reported in the USA that offences such as student tardiness, fighting, suspensions, and arrests had a negative effect on student achievement in science, as well as mathematics, reading, and social studies in secondary schools (Mayer et al., 2000). In a comparison of the US and five Asian top-performing countries in TIMSS 1999, Shen (2005) identified the following differences: A *relatively shorter school year*, *a higher student body mobility*, more *absenteeism* and *frequent class interruptions*, *students spending more time watching TV, playing sports, and working on paid jobs*, *a higher percentage of students from single-parent families, on average, parents having a relatively higher educational background, a higher percentage of students with computers at home,* and *a lower percentage having their own desks*. American parents and students' undervaluing of schooling was attributed to all these variances, and thereby the lower achievement.

Problems that preclude an ethos or atmosphere conducive to academic achievement have been shown to be associated with students from lower SES backgrounds. Therefore the *type of community* in which schools reside has been shown to influence school climate and thereby science achievement (Howie et al., 2008). Teddlie and Stringfield (1993) contrasted low-SES schools with middle-SES schools and suggested creating boundaries to buffer the school from negative influences from the low SES community by increasing contact with a middle-SES community and encouraging parents with high educational expectations to exert pressure for school achievement. In contrast, high expectations from the school, community, and home were found to have a bearing on student achievement (Phillips, 1997). With the assumption that rural and urban schools do not share equitable resource availability, which may account for the variance of academic achievement between the two areas, Webster and Fisher (2000) examined the TIMSS of Australia. Their multilevel analysis failed to show a relationship between availability of resources and achievement in science and mathematics, but found a strong and negative effect of rural location on student science and mathematics achievement. In the Korean TIMSS results, the location of school was proved to be the most important factor behind the variance in science and mathematics between schools (Park & Park, 2006). In South Africa, from the results of TIMSS 2003, Reddy (2006) also compared rural areas with urban areas, finding the differences to be substantial, especially in terms of school resources. South African performance in science has been shown to be stratified, especially by race, despite the abolition of the racial division of education departments in 1994. Such regional variances appear around the world, e.g. in Latvia (Bagata, Geske & Kiselova, 2004), thus, the effects of *school location* should be considered in the study of educational effectiveness.

An achievement-oriented school can improve student learning, as shown in SER previously (Scheerens, 1992; Scheerens & Bosker, 1997), just as parents' high expectations contribute to high achievement. In particular, academic pressure emerging from high expectation was found to improve student achievement (Phillips, 1997).

3.3.5.4 Resources

Resources at the school level involve *building, grounds, gymnasia, library, heating/cooling and lighting, budget for science supplies, general instructional material,* and *budget-related resources like teacher salary* and *student-teacher ratio*. Fraser (1989) found that the science teaching budget per pupil was a significant predictor of science achievement in secondary schools rather than in primary schools in the USA. Although student-teacher ratio within a school does not translate into class size, it is thought to reflect the extent of supporting a school system and indirectly teaching and learning. The largest school-level influence on teachers' practices and classroom culture in the USA was reported to be school poverty (Supovitz & Turner, 2000).

Hanushek (1986) reviewed quantitative studies from a perspective of economics and reported that *school expenditures* including *teacher salary, expenditures per pupil, administrative inputs*, and *facilities* had no strong or systematic relationship with student performance in the USA. However, Hedges, Laine and Greenwald (1994) pointed out that Hanusheck's study used inappropriate statistical methods and poor data, and found the reverse, that is that budget spent on education had a positive bearing on student outcomes. This finding was confirmed by the replication of the previous study (Greenwald, Hedges & Laine, 1996), suggesting that the size of the effect was large enough to show a significant increase in achievement through financial investment.

3.4 CONCLUSION

In this chapter, the literature has been reviewed from two perspectives, viz., SER and science education. School effectiveness research (SER) has identified many effective factors that influence student achievement and explain the achievement variances between educational systems. In the process of the research field development, SER attempted to develop comprehensive education models that can explain educational system in terms of achievement. Researchers apply these models to school improvement projects. In addition, SER is inextricably linked with TER with a common goal to improve student achievement based on the process in the classroom.

As one of the models developed in SER, the Creemers' model offers in particular a view of the teaching-learning perspective. It was recommended to serve as a framework for an international comparative study to view the results of countries which differ from each other in terms of geography, culture, and the socio-economic situation (Kyriakides & Charalambous, 2005). However, most of the attempts have been made to explain school effectiveness using language or mathematics thus far (Kyriades et al., 2000; De Jong et al., 2004; Houtveen et al, 2004) in European countries, but few are in effectiveness of science education particularly in African or Asian countries. Considering these points mentioned above, the current research needs to adapt the Creemers model to reflect the context of developing countries and science education.

On the other hand, research has documented many factors influencing student achievement in science. Research shows such effective factors at the student level as aptitude, attitude, and the social context, such as ethnicity, gender, SES and language. At the classroom level, science curriculum, teacher background, teaching practice, classroom climate, and physical resources-related factors were identified from the literature. At the school level, curriculum management, professional teaching force, school climate, and resources-related factors were distinguished. In the following chapter, the model designed for the study is constructed, based on the factors reviewed in this chapter and some SER models.

CHAPTER 4

CONCEPTUAL FRAMEWORK FOR THE STUDY

4.1 INTRODUCTION

In this chapter, a conceptual framework for the study is built, based on school effectiveness models and factors indicated in literature that influence science achievement of students. The current research project requires a conceptual framework to classify factors influencing achievement in science and to assume relationships between the clusters of the factors. The IEA has offered its own research framework for its international comparative studies since SIMS, and as a matter of course, TIMSS has designed and developed its instrument based on the IEA framework (Travers & Westbury, 1989). The main focus of the IEA research framework is placed on the intended, implemented, and attained curriculum. The collection of data was designed to identify factors likely to influence student learning and to explain international variation in student achievement, reflecting the IEA's main interest of curriculum per se. It has, however, been pointed out that the factors in each unit of the IEA framework are not strictly categorized or concretely defined to operationalize questionnaire items addressed in TIMSS, and that it lacks a theoretical and empirical basis (Bos & Kuiper, 1999). Some researchers who used TIMSS to explore factors likely to influence achievement tried to supplement the IEA framework with other models (Bos, 2002; Howie, 2002).

Furthermore, research concerning TIMSS should take account of the multilevel structure of the data, which consists of achievement in science, and background information obtained on four levels, namely, student, classroom/teacher, school/principal, and context level, which means mainly national level. Taking the points mentioned above and the current research questions together, the requirement of the conceptual framework can be met in a school effectiveness model which explains hierarchically the variance in educational outcomes. SER has identified many factors influencing student achievement as reviewed in Chapter 3. School effectiveness models have been built on these findings, reflecting the hierarchical structure of the educational systems. They include the Scheerens model, the Slavin/Stringfiel model and the Creemers model (Scheerens & Bosker, 1997), all of which share commonalities as they are based on input-process-output, multilevel, and complex causal structure (Scheerens & Bosker, 1997).

In order to build the conceptual framework, in particular, the current research referred to the Creemers (Creemers, 1994) and the Scheerens (Scheerens, 1990) models. The research adopted the Creemers model as it explains variance in outcomes in terms of essential factors of learning theory, viz., time, opportunity, and quality. In Section 4.2, it is comprehensively explored as it forms the main basis of the research framework. In Section 4.3, the Scheerens model is introduced, its factors associated with student outcomes in school in terms of education production function. The research also consulted the Shavelson, McDonnell, and Oakes model (hereafter referred to as the Shavelson et al. model), detailed in Section 4.4. Shavelson et al. (1989) formulated a model to ascertain the state of science and mathematics education in school and to improve student outcomes. Their model accounts for the relationship among clusters within the educational system. Considering all above, the research conceptual framework is proposed in Section 4.5 and conclusions are drawn in Section 4.6.

4.2 CREEMERS' MODEL

Creemers' model has often been used in research, and has been modified to reflect the context of various studies (Bos & Kuiper, 1999; van der Werf et al., 2000; Bos, 2002; Kyriakides & Charalambous, 2005). However, according to Bos and Kuiper (1999), the TIMSS data was based on a weak theoretical framework as clarification and definition of factors are not clear enough to operationalize with questionnaire items, and they had to consolidate the IEA's framework with Creemers' theoretically and empirically well-defined factors. Kyriakides and Charalambous (2005) pointed out that TIMSS' attempt to find factors likely to influence achievement in a student-classroom and teacher-school context is in line with the multilevel models of school effectiveness. They proposed that international comparative studies such as TIMSS could be based on educational effectiveness research, e.g., Creemers' model, although the limitations of the TIMSS data lie in testing final outcomes rather than valued-added progress, with a lack of prior knowledge. Using the multilevel modelling of the TIMSS data and identified factors based on Creemers' model, the results showed that the country-level factors had a greater effect than the student-level and teacher-level factors, as seen in the international comparison. This means that more attention should be paid to the vast differences between the various educational systems rather than the results of TIMSS highlighted in a perspective of summative assessment ranking orders.

The Creemers comprehensive model of educational effectiveness (1994) was developed from a review of the empirical research on effective instruction and consideration of Carroll's learning model. The scope of the two models, those of Creemers and Carroll, differ (De Jong et al., 2004), but they do both attempt to explain variances in student outcomes by the same factors of aptitude, time on task, and opportunity to learn. Placing more emphasis on the classroom and teacher, Creemers (1994) focuses on the teaching-learning process in the classroom, where all factors or variables that contribute to educational outcomes exist. The quality of instruction in the classroom depends on three components, namely curriculum, grouping procedure and teacher behaviour, as shown in Figure 4.1 (below). Amongst them, the most important factor is teacher behaviour, because all those factors depend on how a teacher runs his or her lesson. In other words, it is how teachers implement the curriculum that determines student outcomes, not the curriculum itself, and even grouping which positively influences outcomes can be realized by the teacher's capacity.

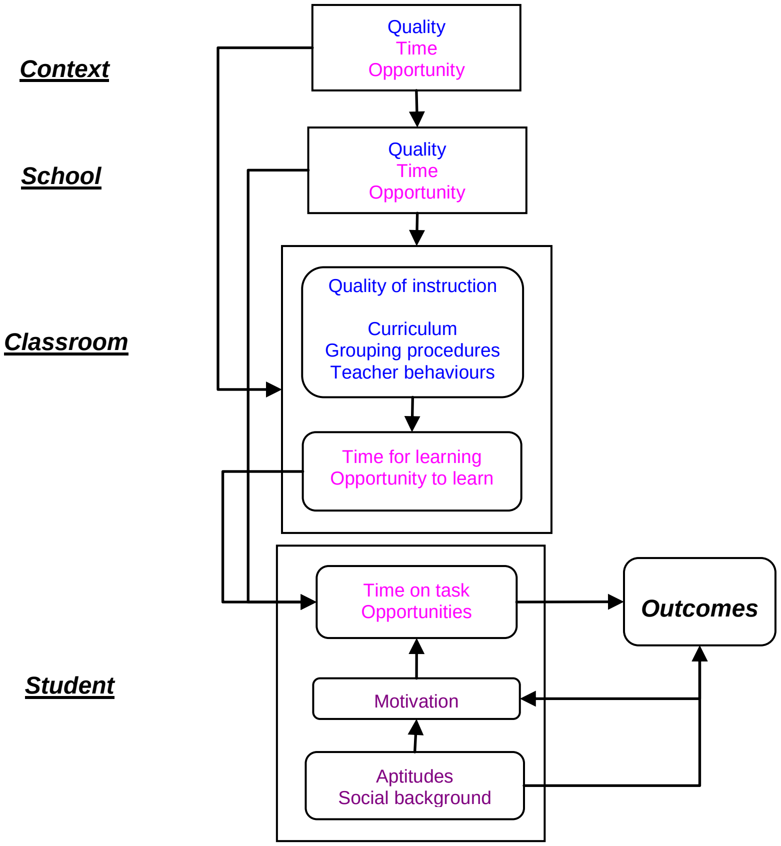

Figure 4.1 **Creemers' comprehensive model of educational effectiveness (1994)**

Another feature of the model is the three components, viz., quality, time and opportunity, all of which influence achievement across levels. These components emerged from Carroll's (1963) five factors, namely students' aptitude, perseverance, ability to understand instruction, quality of instruction and opportunity to learn. While Carroll attempted to consider these as time required and explain student learning in terms of individual factors, Creemers places more focus on educational factors, especially quality of instruction within class, which in the form of curriculum, grouping procedure, and teacher behaviour at the classroom level influences time and opportunity at classroom level. They in turn influence time on task and opportunity to learn at the student level and eventually student outcomes. Furthermore, school-level and context-level factors are defined in terms of quality, time, and opportunity, and they in turn influence the classroom level. This attempt can lead to consistently viewing educational effectiveness from a teaching-learning point of view.

In attempting to account for the variance of achievement among students of the two countries, Korea and South Africa, this study assumes that the students sampled in the two countries are learners who grow up through common psychological development, although their contexts such as culture and socio-economic situation are different. Therefore, the Creemers model, based as it is on teaching-learning theory, suits the current research. Analysis from the teaching-learning perspective may offer another insight into the variances, since TIMSS focuses on the effectiveness of curriculum and instruction on student learning, and thereby provides relevant data (Martin et al., 2004). The different levels of the educational system accounted for by Creemers are student, classroom, school and context, all related to each other and contributing to educational outcomes. More detail on each level is now provided separately, for greater clarity.

4.2.1 THE CONTEXT LEVEL

Creemers' model places the context level above the school level, as contextual conditions influence the school level and the classroom level. Context-level factors are differentiated into time, opportunity, and quality, as in other levels. Conditions to develop and enhance quality at the context level are national policies for effective education, indicator systems or national policies on evaluation, national testing systems, training and teacher support systems, and funding of schools based on outcomes. Conditions for optimal time at the context level are national guidelines for the time schedules in school and supervision of the maintenance of schedules. Conditions for opportunity to learn at the context level include the national guidelines and rules for the national curriculum.

At the context level, consistency, constancy, and control for effective instruction should be guaranteed as formal characteristics. It is of interest that although Creemers defined and acknowledged as important the availability of materials, teachers and other components that support education in schools and classrooms, he did not emphasise it as much Scheerens (Section 4.3).

4.2.2 THE SCHOOL LEVEL

At the school level, Creemers restricted the scope of school-level factors to conditions for the classroom level factors, with conditions for effective instruction at the school discerned in terms of time, opportunity to learn and quality. Conditions for time at the school level are the time schedule for subjects and topics, rules and agreement about time use, and the maintenance of an orderly and quiet atmosphere, so that learning time can be increased in an orderly climate. Conditions for opportunity to learn at the school level are the development and availability of a curriculum, school working plan or activity plan, consensus about the mission of the school, and rules and agreements about implementation of curriculum with respect to transition from one class to another or from one grade to another.

As indicated by the arrows in Figure 4.1 (above), the school level is influenced by the context level. In the same way, quality, time and opportunity at the school level influence education at the classroom level and at the student level. However, as Creemers stated, in order for the factors to effectively operate for the better outcomes, characteristics should be identified. As far as effective characteristics at the school level are concerned, four are presented to produce effective education: ‘consistency’ between three main components at the school level, ‘cohesion’ of all members of school, ‘constancy’ for the total school career of students, and ‘control’ to assess student and teacher, as well as a well-organized school climate.

4.2.3 THE CLASSROOM LEVEL

The Creemers model emphasizes the classroom level in particular, since this is where learning and teaching take place and effectiveness of education created. For this reason, the model is developed around the instructional conditions in a classroom. A central component, quality of instruction consists of curriculum, grouping procedure, and teacher behaviour, which interrelate and thus maximize quality of instruction. This quality of instruction in turn influences time for learning and opportunity.

The model offers more distinguishing factors from reviews of research in relation to curriculum, grouping procedure, and teacher behaviour (Table 4.1, below). Firstly, curriculum refers to the documented materials at the classroom level used by teachers and students in the instructional process. Creemers argues that the degree of the implementation of curriculum by teachers is more influential on student achievement than curriculum itself. Secondly, grouping based on mastery learning is strongly related to evaluation, feedback and corrective instruction to overcome deficiencies in learning. The grouping of students can also influence the allocation of time and opportunities for learning. On the other hand, the effect of grouping depends on the capacity of teachers. Grouping procedures seem to reflect the Dutch, US, and UK education systems, which practise streaming or tracking in primary and secondary education to overcome the difference between students. Thirdly, teacher behaviour can be translated into two sub-components, viz., management behaviour to control the class, to prepare the students for learning and to maintain learning, and instructional behaviour related to teaching.

Apart from the main components explained above, Creemers stated that there are effective interactions between the components at each level. For example, at the classroom level, ‘high consistency’ between three components can cause a synergistic effect and eventually improve student achievement. Without consistency, the results could be worse. For example, when C2005, a new outcomes-based curriculum, was implemented in South Africa, teachers did not have the chance to adapt to it or adopt it, causing considerable confusion among teachers (Hoadley & Jansen, 2002). The curriculum has been revised subsequently but that a similar problem still exists. This shows the importance of developing consistency between the components in order to successfully realize effective education.

4.2.4 THE STUDENT LEVEL

Individual factors such as aptitude, background, and motivation determine student outcomes at the student level. In addition, outside-controllable factors such as time on task and opportunity to learn also influence student outcomes. In particular, the two factors are important as they might be controllable in the educational system. All those factors are derived from Carroll’s model, but it should be noted that opportunity to learn is defined as supply of learning material, experiences and exercises, as opposed to time dimension as in Carroll’s model. As defined in Chapter 3, aptitude indicates what a student already knows, and involves general ability and prior learning. The background factor reflects socio-economic status (SES), an important factor in explaining student outcomes. Creemers considered motivation only at the student level, while some researchers see motivation as also resulting from teacher’s or school’s expectation (Papanastasiou, 2002; Lyons, 2006). Motivation affects student achievement and vice versa, as shown by the two-way arrow in Figure 4.1

(above). In the conceptual model for the study built in Section 4.5, the term ‘motivation’ was replaced by ‘attitudes’ to encompass broader meaning, since attitudes imply more comprehensive meaning, such as feeling, cognition, and behaviour (Simpson et al., 1994).

In summary, Creemers (1994) classified four levels, viz., context, school, teacher, and student, and three components, i.e., quality, time, and opportunity to learn. The details of components in each level are described in Table 4.1 (below).

Table 4.1 ***The Creemers' comprehensive model of educational effectiveness (1994)***

Levels	Components		Details of components	Formal criteria
Context	Quality		Policy focusing on effectiveness Indicator system/policy on evaluation /national testing system Training and support system Funding based on outcomes	Consistency Constancy Control
	Time		National guidelines for time schedules Supervision of time schedules	
	Opportunity		National guidelines for curriculum	
School	Quality (educational)		Rules and agreements about classroom instruction Evaluation policy /evaluation system	Consistency Cohesion Constancy Control
	Quality (organizational)		Policy on intervision, supervision, professionalization School culture inducing effectiveness	
	Time		Time schedule Rules and agreements about time use Orderly and quiet atmosphere	
	Opportunity		School curriculum Consensus about mission Rules and agreements about how to implement the school curriculum	
Classroom	Quality of instruction	Curriculum	Explicitness and ordering of goals and content Structure and clarity of content Advance organizers Evaluation Feedback Corrective instruction	Consistency
		Grouping procedures	Mastery learning Ability grouping Cooperative learning highly dependent on Differentiated material Evaluation Feedback Corrective instruction	
		Teacher behaviour	Management /orderly and quiet atmosphere Homework High expectations Clear goal setting Restricted set of goals Emphasis on basic skills Emphasis on cognitive learning and transfer Structuring the content Ordering of goals and content Advance organizers Prior knowledge Clarity of presentation Questioning Immediate exercises Evaluation Feedback Corrective instruction	
	Time for learning Opportunity to learn			
Student	Time on task Opportunities used Motivation Aptitudes Social background			

4.3 SCHEERENS' MODEL

The Scheerens model (1990), an integrated, multilevel school effectiveness model, attempts to explain school effectiveness from a systematic point of view, as opposed to Creemers' model which places emphasis on classroom processes from a perspective of teaching and learning theory. Although Scheerens acknowledged the importance of classroom level factors in school effectiveness, his model places more emphasis on the functioning of a school as an organizational system, following his definition of effectiveness as productivity. Such an emphasis on organizational structures or managerial processes is more appropriate for meeting demands of policymakers or decision-makers, who find manipulative factors to promote school effectiveness, than for practitioners such as teachers, who want to improve teaching and learning in the classroom.

As depicted in Figure 4.2 (below), Scheerens adopts a two-dimensional analytic scheme which contains context-input-process-output and educational multi-levels, viz., pupil, classroom, school, and environment. The context-input-process-output dimension reflects economic productivity and the pupil-classroom-school-environment dimension indicates a hierarchical and nested structure of the school system. The context and input cluster mainly involves resource-related factors, whereas the school and classroom level concerns attitudes, ethos, climates, and teaching practice. From an additional review of previous literature and research (Scheerens & Bosker, 1997), overarching factors related to educational effect at the classroom and the school level were explored, together with the definitions.

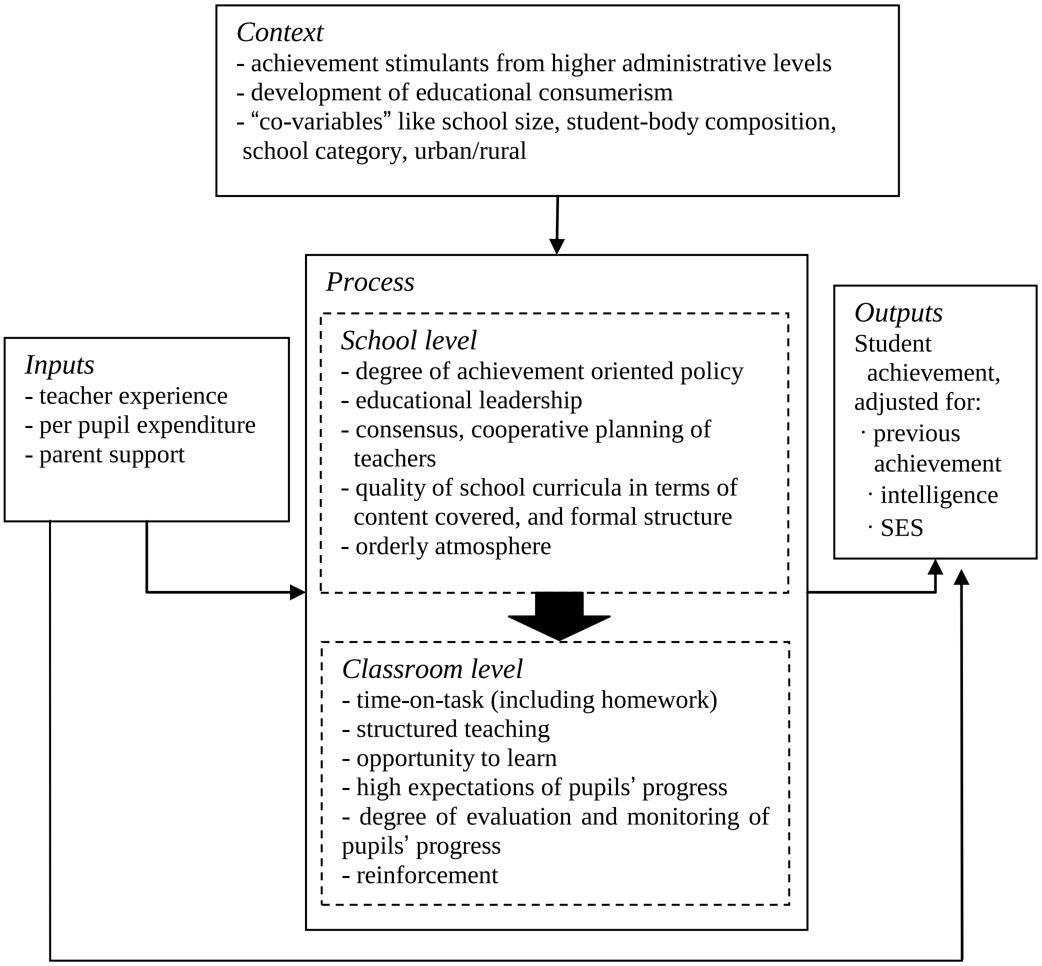

Figure 4.2 **Integrated model of school effectiveness (Scheerens, 1990)**

The main factors identified from the aforementioned review are as follows:

1. Achievement orientation, high expectations, teacher expectations
2. Educational leadership
3. Consensus and cohesion among staff
4. Curriculum quality, opportunity to learn
5. School climate
6. Evaluative potential

7. Parental involvement
8. Classroom climate
9. Effective learning time (classroom management)
10. Structured instruction
11. Independent learning
12. Differentiation, adaptive instruction
13. Feedback and reinforcement

Some of these factors, such as educational leadership, school and classroom climate, or parent involvement, are not identified in Creemers' model, and so may be considered as making up for gaps in it.

4.4 SHAVELSON, MCDONNELL, AND OAKES' MODEL

Shavelson, McDonnell, and Oakes (1989) developed a comprehensive model of the educational system, aiming at an indicator system that would measure the state of mathematics and science education. Their model could help policymakers determine the nature of current problems, evaluate the factors influencing educational trends, monitor the effects of policy, and identify interventions to improve student performance.

Shavelson et al.'s model features many arrows, which indicate the direction of influence, as shown in Figure 4.3 (below). Looking at the arrows around 'achievement', educational outputs or outcomes are directly influenced by instructional quality, together with student background. The instruction quality, in turn, is affected by the school, the curriculum, teaching quality, and student background. The school quality can influence the instructional quality by working conditions, including class size, classroom resources, occupational support, and school-wide standards. The curriculum quality can have influence on the instructional quality by giving students the opportunity to learn, and the teaching quality can affect the instructional quality by teacher qualifications and general patterns of teaching practices.

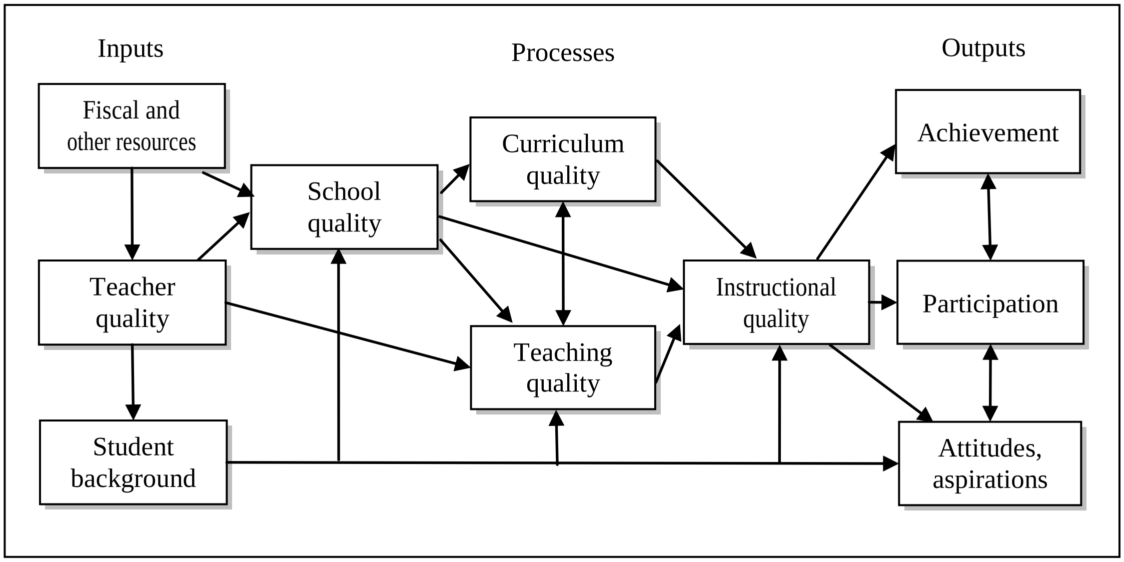

Figure 4.3 **A comprehensive model of the educational system (Shavelson et al., 1989)**

What should be highlighted in the model compared to the two presented above is that the instructional quality is affected by student background as well as school, teacher and curriculum quality. School effectiveness models such as those of Scheerens and the Creemers assume that the instructional quality in classroom is affected only by curriculum, grouping procedures, teacher behaviour or higher-level factors such as educational leadership, but not by lower-level factors such as student attitudes. There is no doubt that the quality of science education rests on the quality of instruction that students receive. This in turn is largely determined by such teacher factors as the qualifications of science teachers, and school factor such as the conditions under which these teachers work. Taking into consideration that there are not only teachers but also students in the classrooms, and that teachers should focus on both teaching subject matter and enforcing classroom discipline with the dual responsibilities (Shavelson et al., 1989), student factors such as attitudes, family background and previous performance can be related to the instructional quality. Consequently, relationship between factors and levels should be considered in a reciprocal way, not just as one directional.

4.5 CONCEPTUAL FRAMEWORK FOR THE RESEARCH

The conceptual framework for the research is mainly built on the three models explored previously, namely Creemers’, Scheerens’, and Shavelson et al.’s. Furthermore, factors specific to science achievement are combined in the framework. Broadly stated, the new model differs from that of Creemers in two important aspects, namely inclusion of resources at each level, and reclassification of sub-components in quality at classroom and school level. As pointed out above, Creemers examined all the factors likely to influence student achievement in terms of time, opportunity, and quality, thereby limiting possible factors to these three categories, consequently, risking missing important factors such as resources and leadership.

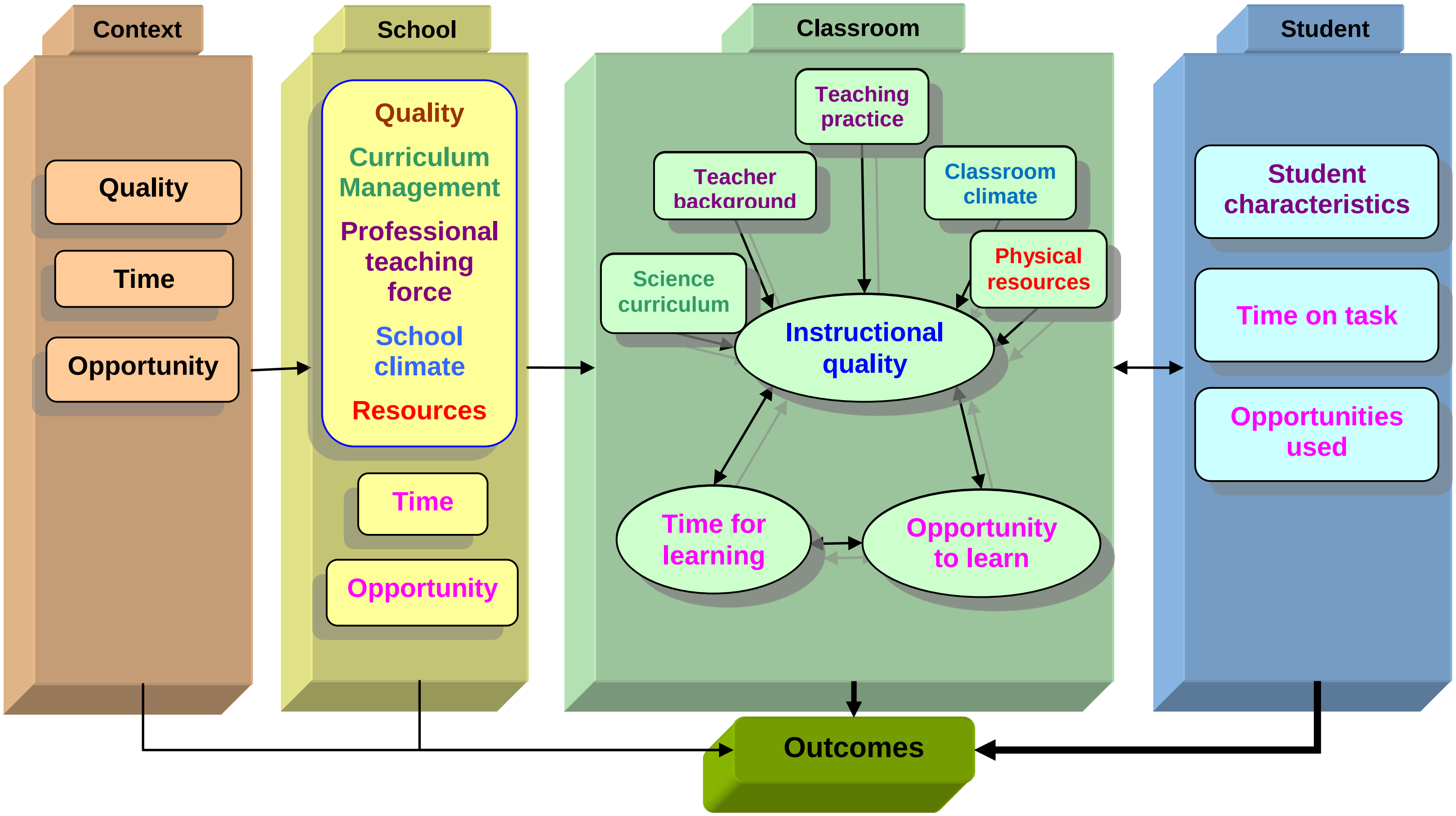

Figure 4.4 **A proposed model of effectiveness of science education**

In terms of resources, Creemers (1994) and Scheerens (1992) regarded them as an input factor. Creemers did not include resources in the structured model although he mentioned resources at context level, together with the definition as mentioned above. Scheerens showed resources in the input and the context unit. In the new model, mainly based on the Creemers model, as shown in Figure 4.4 (above), the resource factor is added to quality component at classroom, school, and context level. The resources correspond to infrastructure or instructional materials to support teaching and learning, such as the library, laboratory, experimental apparatus, or computers.

In particular, resources are important in the current research for two reasons. One is that this research concerns developing countries, in which resources are more likely to influence student achievement than in developed countries (Fuller, 1987; Glover, 1992; de Feiter et al., 1995; Scheerens, 2001; Reddy, 2006). The other is that the research focuses on the subject of science, which is thought to depend much more on physical resources than other subjects (Rogan, 2000). This is confirmed by the previously reviewed literature.

As the second aspect of the new conceptual framework, a reclassification of sub-components was made to encompass some effective factors which are not emphasized in the Creemers model. The quality component at the school level contains curriculum management, professional teaching force, school climate, and resources, including time and opportunity to learn. Instructional quality at the classroom level consists of science curriculum, teacher background, teaching practice, classroom climate, and physical resources. Based on the literature review in Chapter 3, the climate factor and resource factor are included at both levels. As compared to Table 4.1 (above), other sub-components were shown in more detail in Table 4.2 (below).

Table 4.2 ***Proposed factors at the student, classroom, school, and context level***

Levels	Factors		Details of factors
Student	Time on task		The time spent on homework, private tutoring, and outside-school activities related to science
	Opportunities used		Absenteeism, Participation in science course, Homework, Tutoring
	Student characteristics	Aptitudes towards science	Prior achievement
		Attitudes towards science	Self-confidence, Motivation, Enjoying science, Valuing science
		Social context	SES, Parent education, Books in home, Parent involvement, Peer environment, Ethnicity, Language, Gender
Classroom	Instructional quality	Science curriculum	Science textbook and workbook
		Teacher background	Academic skills, Teaching assignment, Teacher experience, Degree, Certification, Major area of study, Professional development, Gender
		Teaching practice	Direct instruction-Structured teaching, Questioning, Manipulation-practical work, Enhanced material, Assessment-test, feedback, reinforcement, Inquiry-problem solving, Enhanced context-linkage with daily life, Collaborative learning
		Classroom climate	High expectations, relationships between teachers and students, and among students, Management /orderly and safety atmosphere Teachers' attitudes towards student and science teaching Students' attitudes towards class, Student disruption, intrusion, and interruption
		Physical resources	Labatory, Equipments and materials for science experiments, Computer, Software, Internet access, Video-audio facility, Teaching condition, Class size
	Time for learning		The time assigned by science teacher to teach science contents, Instructional time
	Opportunity to learn		The science contents taught by science teachers
School	Quality	Curriculum management	Rules and agreements about classroom instruction, science-related extracurricular activities, Curriculum-related task or decision-choosing textbook, determining course content, course offerings, student grading policies, assigning teachers to science classes, and instructional days or hours per year
		Professional teaching force	Educational leadership, Consensus or cohesion among school staffs including teachers, Stable body of teachers, Regular meeting of teachers
		School climate	High expectation, Achievement orientation, Community SES or School location, School discipline-student disrespect for teachers, absenteeism, tardiness, bullying, fighting, and theft, Higher student body mobility, Orderly and safety atmosphere
		Resources	Building, Grounds, Gymnasia, Library, Heating/cooling and lighting, Budget for science supplies, General instructional material, Budget-related resources-teacher salary, student-teacher, expenditures per pupil, administrative inputs, and facilities
	Time		Time schedule per week and per year, Duration of class, Rules and agreements about time use, Frequency of field trips
	Opportunity		School science curriculum offered, Science field trips Rules and agreements about how to implement the school science curriculum Curricular differentiation in science
Context	Quality	Curriculum	Policy focusing on effectiveness Indicator system/policy on evaluation / National testing system Training and support system, Policy on science curriculum
		Resources	Expenditures per pupil, Expenditures as a percentage of per capita income Average teacher salary, Pupil/ teacher ratio , Funding based on outcomes
	Time		National guidelines for time schedules Supervision of time schedules
	Opportunity		National guidelines for curriculum

Another focus should be placed in particular on the classroom level in the new model shown in Figure 4.4 (above). Capacity to be successful in terms of implementation depends on various factors such as resources, teacher, student, and school support (Rogan & Grayson, 2003; Rogan & Aldous, 2005). Therefore, the point made here is that teaching practice and teaching conditions mainly determine instructional quality, but it cannot depend only on teacher behaviour, curriculum or grouping factors as described in the Creemers model. As in the model of Shavelson et al. (see Figure 4.3, above), instructional quality can be influenced by school factors, student factors, teaching quality, and curriculum. The arrow drawn from the student level to the classroom level in Figure 4.4 (above) reflects this point. The studies based on constructivism have evidenced that the active role of the learner is important to good subject matter teaching (Brophy, 1992; Scheerens, 1997). This is decidedly true in science teaching in particular. The main assumption in multi-level educational effectiveness models, namely that higher levels facilitate operations of lower levels (Scheerens, 1997), should therefore be re-considered. Accordingly, the linkages between clusters are not simple one-way processes as in the Creemers model.

On the other hand, there is a need to examine the deficiencies of the model mainly adopted, the Creemers model, and to explain the reason for modification. Creemers considers the classroom as key to effective instruction and looks upon the school and context levels as conditions to facilitate effective instruction in the classroom. When these levels are defined as organizational conditions to support classroom instruction, a lack of interrelationship between them occurs. To avoid this lack and to investigate factors other than those found at the classroom level in the same vein as them, he defined school-level and context-level factors in light of three components, namely, time, opportunity to learn, and quality.

Nonetheless, this definition restricts the selection of school level factors only to those factors conditional for, and directly related to, quality of instruction, time or opportunity to learn (Creemers et al., 2000). Actually, his attempt seems to miss some important factors related to student outcomes, especially at other levels. For example, educational leadership, which has been acknowledged to have an effect on achievement (although not in the Netherlands) (Creemers, 1994), is not found clearly in his model, even though he stated teacher's management at the classroom is in the similar vein. As for resources, he mentioned these but did not specify them in the model, as mentioned above. Given that the TIMSS data to be examined in the research offers information about these factors, more should be added to the Creemers model. Exhaustive factors shown in Scheerens and Bosker (1997) supplemented this deficiency in the model built for the study.

Although each component is distinguished as shown in Figure 4.4, they interact and are interrelated. Furthermore, it should be kept in mind that those interactions or interrelation are not causal but correlational. In designing the new model, some effort was made to avoid a labyrinthine scheme and to parsimoniously use arrows, which show linkages across the factors and the levels. It is therefore understood that there are more linkages between factors than shown by the arrows in Figure 4.4.

4.6 CONCLUSION

In this chapter, the research framework was formulated as described up to this point. The framework consulted some representative educational effectiveness models, including the Scheerens model and the Creemers model. The models referred to shared commonalities as based on input-process-output, multilevel, and complex causal structure (Scheerens & Bosker, 1997). In particular, the current research investigated thoroughly the Creemers and reflected some factors proposed in the Scheerens model. It is recognized that Scheerens offers factors associated with student outcomes in school in terms of education production function, while Creemers explains variance in outcomes in terms of essential factors of learning theory, viz., time, opportunity, and quality. Also, the Shavelson, McDonnell, and Oakes model contributed to building the model when accounting for the relationship among clusters within the educational system.

Accordingly, the theoretical framework of the research is based on the Creemers model and considers the factors shown in the Scheerens model. Finally, factors specific to science explored above are incorporated and, as a result, some modifications are made reflecting the model of Shavelson et al. (1989), where relationships between levels and factors in educational systems are clear. Just as effective teacher behaviour must be qualified in different grades or contexts (Brophy & Good, 1986), the possibility exists that the conceptual framework for the research may need to be modified depending on systems or subjects. The model developed here, which emphasizes resource factors, can contribute to SER in developing countries and in science.

CHAPTER 5

RESEARCH DESIGN AND METHODOLOGY

5.1 INTRODUCTION

The purpose of this research is to explain the difference of science achievement between Korea and South Africa by undertaking a secondary analysis of existing data, namely TIMSS 2003. As this is a secondary analysis, and given that it involves quantitative methods and seeks to explore the nature of relationships in social phenomena, this research falls within a post-positive paradigm. Post-positivism emerged after World War II, as an alternative to positivism, which is applicable to the natural science but not to the social sciences (McMillan & Schumacher, 2006; Cohen et al., 2007).

Positivists believe that causes that explain effects or outcomes can be acquired by scientists' observations and measurements, since knowledge is objective and tangible. Accordingly, one would understand, explain, and predict phenomena in the world. However, while this may work well in the natural sciences, the social sciences research complex human behaviour that reflects the unconscious mind and is therefore not subject to such rational methodology (Cohen et al., 2007).

Post-positivism and positivism have in common quantitative approaches, such as observation and measurement, but the degree of accuracy is different. Knowledge of objective reality can be identified by means of careful observation and numerical measurements but, under post-positivism the objectivity, or generalisability, can be ensured by multiple measurements. As human behaviour and quality of social phenomena are complex and often intangible, the measurement or research may be imperfect. Therefore, post-positivism allows for some limitations, and contextual factors that account for the complexity of human nature (Cohen et al., 2007). The current research is located in a post-positivism paradigm, based on findings identified previously and examining data from a perspective of a theory that is attempts to enforce, then modify, and finally improve in terms of its generalisability and objectivity.

The rest of the chapter is as follows: Secondary analysis based on survey data is discussed in more detail in Section 5.2, after which the research questions are examined in Section 5.3. Sections 5.4, 5.5, and 5.6 briefly introduce the sampling, data collection and instruments. Thereafter, data analysis procedures for the study are described along with presenting appropriate statistical processes (5.7). Thereafter, correlation analysis and multilevel analysis are introduced in Section 5.8 and 5.9. Methodological norms in TIMSS are discussed (5.10). Ethical considerations related to the research are discussed (5.11), and conclusions are drawn in Section 5.12.

5.2 SECONDARY ANALYSES OF DATA

Secondary analyses can be defined as any further research that studies diverse problems with the same data as previously collected by other researchers to study a problem (Herrnson, 1995). The intention of using secondary analysis is to obtain a more in-depth understanding of the subject matter at hand, or present interpretations, conclusions or knowledge additional to, or different from, those presented in the primary study (Dale, Arber & Procter, 1988). Given the aforementioned points, secondary analyses can be seen as a good way to increase knowledge in research (Herrnson, 1995). In some cases, secondary analyses may aim at generating hypotheses and identifying critical areas of interest that can be examined during primary data gathering activities.

Regardless of the intention of secondary analysis, there are some advantages and disadvantages that should be acknowledged. In light of advantages, secondary analysis may be conducted for a number of reasons, including data quality, adequate sample size, time efficiency, and cost effectiveness (McMillan & Schumacher, 2006). The advantages are explored in more detail as follows:

Data quality: Taking into consideration the aspect of data quality, the TIMSS data was proved to offer a high degree of validity and reliability as TIMSS developed instruments ensuring well-designed processes, careful fieldwork and attention to methodological norms such as validity and reliability, consistency over time, and national representativeness of their large sample size (Dale et al., 1988). When primary data has a high degree of validity and reliability, it is evident that this applies to their use in a secondary analysis. The reliability and validity of research analysis can be enhanced, particularly with a large sample.

Sample size: In addition large nationally representative samples, TIMSS presents data at many levels, including student, class, school, and context, and so provides the most appropriate data to answer the current research questions. The secondary analyst may choose only one among various levels, or examine individuals within the context of the larger group or organization. In particular, the advantage of studying individuals nesting in a group is preferred in education research, where student achievement or attitudes can be examined within the school context.

Time and cost: Another advantage of secondary analysis is saving time and costs. Unlike formal primary data collection and analysis processes, secondary analysis can be carried out more quickly and, therefore, the cost is reduced. This kind of financial saving encourages the secondary analyst who has no source of funding or few resources for carrying out the primary data collection to become involved in secondary analysis. While large-scale and worldwide studies, such as IEA, take place over a considerable time span and require substantial funding, conducting a secondary analyses on these studies is easily effected by the global availability of the data.

On the other hand, there are some disadvantages to secondary analysis that should be noted. Occasionally information or data is not always what might be needed to answer the research questions, and so might have the potential to bias the study. Furthermore, secondary analysts are more likely to become overwhelmed by the considerable volume of data available, making it difficult to determine its quality (McCaston, 1998). Therefore, it is important to develop a strong theoretical framework beforehand, and secondary data should be examined and presented with in-depth interpretation and analysis within the theoretical framework.

This is a secondary analysis of the survey for TIMSS 2003 and as such is research in which the researcher has not been involved in the actual collection of the data (Bryman, 2004). Survey research can provide an analytical framework for research while less structured forms of methods, such as interviews or ethnographic observations, may enhance insights and understandings on the social phenomena in question (Dale et al., 1988). Survey research tends to be regarded as suitable for exploratory and confirmatory analysis which may lead to, where possible, a modification of the original theory. Therefore, secondary analyses using survey data can benefit from different methods and theoretical perspectives to answer the identified research questions.

5.3 DISCUSSION OF RESEARCH QUESTIONS

The current study brought up the two research questions to ascertain the difference and similarity between Korean and South African science achievement. A research design and method to be used can be determined depending on the two questions to be answered. Therefore, the main two questions were examined in terms of method.

The first main question is '***To what extent does TIMSS 2003 reflect factors related to effective science education?***' The first main question aims to identify, from literature, factors influencing performance in science. In order for this question to be answered, the study examined previous research comprehensively and adapted the conceptual framework from the literature consulted. As a result, many factors specific to science were identified, as explored in Chapter 3. In the process of the exploration, SER has played a role in directing the way in which the factors should be identified. However, these factors and the framework should be verified empirically using the current analysis.

Since TIMSS collected data at student, teacher, classroom, school, and context levels, it would be reasonable to examine factors corresponding to each level. Accordingly, the first research question can be broken down into three sub-questions: '*Which factors at the school level influence science achievement?*', '*Which factors at the classroom level influence science achievement?*', and '*Which factors at the student level influence science achievement?*'. An exploration of variables at different levels was carried out to address these questions.

As the first step of verification, the TIMSS data related to information was examined in terms of the framework developed in Chapter 4, specifically that regarding the background of the students, the teachers and the classroom, and about the schools and their principals. This was then compared to the constructs in the conceptual framework depicting teachers' characteristics, including classroom practice, students' characteristics (e.g., SES and attitudes), and school characteristics, (e.g., facilities). Thereafter, items in the TIMSS questionnaires were explored and selected for further analyses, namely factor, reliability, and correlation analyses. This resulted in a number of specific issues influencing student performance in science, the results of which are presented in Chapter 6 and 7.

The second question is '***To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?***' This arose from a perspective of international comparative studies, which, like the current research, attempts to find similarities and differences in background factors related to student achievement (Bos, 2002). In order for this to be investigated, it needs to be answered step-by-step as follows: '*Which factors influencing achievement are generic when comparing Korea and South Africa?*', '*Which factors influencing achievement are specific to Korea?*', '*Which factors influencing achievement are specific to South Africa*?', and '*How do these generic and specific factors explain the difference in the performance of the two countries?*'

For the study to reflect on such hierarchical structure of the data influencing student achievement, the research method adopted a multilevel approach to analysis, making it possible to examine influences between the levels as well as each level's impact on student achievement. In addition, the multilevel analysis involves the interaction between and within each level, allowing factors specific to students, classroom, and school to be studied simultaneously. The results of this multilevel analysis are presented in Chapter 8.

In terms of multilevel aspects, previous research has shown that school-level factors are more likely to influence student achievement in science in developing than developed countries (Heyneman & Loxley, 1983; Fuller, 1987; Fuller & Clarke, 1994). It is therefore believed that school-level factors are more likely than student-level factors to play a significant role in South African Grade 8 student achievement in science. In contrast, given the highly competitive educational zeal displayed by Korean students (Martin, Mullis, Gonzalez & Chrostowski, 2004), it is plausible that student-level factors will be found to influence student achievement more than other level factors.

Cross-national comparative research such as the current study seeks to understand similarities and differences in background factors related to student achievement measured in TIMSS. When these questions are answered, one can then investigate whether factors that are important for consideration in South Africa are also important to consider in a Korean context, or which factors generally apply to both countries. However, commonly identified factors may lead to generalizations about the effect of particular student, teacher, classroom or school-level across educational systems in both Africa and Asia. Ultimately, answering these questions also assists in understanding the educational contexts in each country and the reasons for cross-national differences in achievement.

5.4 SAMPLE

TIMSS studied achievement in two target populations, namely, population 1, consisting of mostly 9-year-olds at the time of testing, and population 2, consisting of mostly 13-year-olds at the time of testing. This study has focussed on population 2, consisting of Grade 8 learners. As South Africa did not participate in TIMMS 2007, the TIMMS 2003 results were the most recent data that could be used for this study.

The Korean sampling frame for TIMSS 2003 included 607,123 students with the teacher sample being selected from the class of the sampled school automatically. Some schools were excluded for various reasons, such as their being situated on far-away islands, or in remote areas, or because they were too small. Accordingly, the sampling frame resulted in 601,123 students as of April in 2002 (Park, Hong, Lee & Cheon, 2003). Korea adopted an administrative district as an explicit stratification variable and constructed 16 sampling frames from which the sample was drawn. In addition, an implicit stratification was identified, namely urbanization and gender (Park et al., 2003). As a result, Korea sampled 151 schools with 16 explicit strata by province and

83 implicit strata by urbanization and gender, resulting in 5,300 learners participating in the study (Martin, Mullis & Chrostowski, 2004).

South Africa stratified the sample by two dimensions, viz., by province and language of teaching and learning. Consequently, 265 schools were sampled with 9 explicit strata by province and 19 implicit strata by language, resulting in approximately 9,000 learners being tested across the provinces (see Table 5.1, below). Where class size was over 50 learners, 40 learners from the whole class were sub-sampled with probability-proportional-to-size (PPS) (Martin, Mullis & Chrostowski, 2004).

It should be noted that the number of schools sampled in South Africa exceeds those of most countries, which sampled around 150 schools. This oversampling was designed to produce provincial statistics across the nine provinces (Reddy, 2006) as it was suspected that a broader range of gaps within the country in terms of education, race, and social-economic status would emerge, and thus it was intended to get in-depth and precise insight into these gaps (Howie, 2001).

Table 5.1 ***Schools sampled in Korea and South Africa***

	Schools sampled	Sampled schools participating	Replacement school	Total schools	Total learners
Korea	151	149	0	149	5309
South Africa	265	241	14	255	8952

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004

5.5 DATA COLLECTION

The TIMSS 2003 data was collected at the end of the school year. In countries in the Northern Hemisphere, where the school year typically ends in June, the assessment was administered in April, May, or June 2003. In the Southern Hemisphere, including South Africa, the school year typically ends in November or December so the assessment in these countries was conducted in October or November 2002 (Martin, Mullis & Chrostowski, 2004). Korea tested from 14 to 19 April 2003 (Park et al., 2003) and South Africa tested from 21 October to 1 November 2002 (Reddy, 2006).

Each participating country was responsible for the data collection, using standardized procedures developed for the study and based on training manuals created for school co-ordinators and test administrators. As explained in Chapter 2, a Quality Control Monitor (QCM) appointed in each country monitored the procedures for her/his country. Additionally, the QCM interviewed the National Research Coordinator (NRC) and visited a selection of the sampled schools. The school co-ordinators and field workers took part in the training course run by the Korea Institute of Curriculum and Evaluation (KICE) two weeks in advance of the administration. The training course involved 34 to 40 schools at a time and took place four times across the country. A similar training procedure took place in South Africa.

Specifically in Korea, the test was supposed to be administered to Grade 8 in February 2003, however, there was a problem because at that time Korean schools had only just been open for a few days, the academic year having ended in February and the new one started in March. The Korean administration date (14 to 19 April 2003) was negotiated with the sampled schools and is shown in the international report. However, because the academic year had only just begun, in agreement with the international study centre, the test was administered to Grade 9 students but the students tested were to be reported as Grade 8, and all science teachers were to respond to the questionnaire reporting the Grade 8 classes taught by them the previous year (Park et al., 2003).

South Africa conducted the test under the auspices of the Assessment Technology and Education Evaluation Research Programme at the Human Sciences Research Council (HSRC). Just as in other southern hemisphere countries, South Africa administered TIMSS instruments to Grade 8 students at the end of their academic year, which is from 21 October to 1 November 2002. The HSRC assigned *AC Nielsen and Mictert*, an outside agency, for the administration of the instruments in schools. This body trained their data collectors using a manual prepared by the TIMSS International Study Centre (ISC) to assist when TIMSS is administered in the sampled schools (Reddy, 2003). School staff was also supposed to help with logistical arrangements, such as identifying testing locations.

In both countries, sampled students each used one booklet containing both mathematics and science items for 90 minutes and responded to the questionnaire for 30 minutes, taking a break between the assessment and the questionnaire.

The TIMSS 2003 data for Korea and South Africa was accessed from the IEA website, which is in the public domain[8].

5.6 INSTRUMENTS

TIMSS 2003 consisted of mathematics and science achievement test items, as well as questionnaires. The achievement test was designed to assess mathematics, science knowledge and skills based on school curricula for Grade 8 learners. As explored in Chapter 2, assessment is addressed by the form of a booklet containing both mathematics and science items, and each student takes one booklet. For the purposes of this study only the assessment and questionnaires concerning science will be focussed on. The assessment items were developed using the TIMSS assessment framework and specifications, as

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[8] http://www.iea.nl/iea_studies_datasets. html.

well as depending on the contribution of NRCs during the entire process of the regular meetings in which the NRCs could add their inputs (Martin, Mullis & Chrostowski, 2004). The questionnaires were designed to provide a context for the performance scores, focusing on students' backgrounds and attitudes towards science, the science curriculum, teachers of science, classroom characteristics and instruction, and school context (Martin, Mullis, Gonzalez & Chrostowski, 2004). The details of two instruments are provided in the following sections respectively.

5.6.1 THE SCIENCE ASSESSMENT

The science assessment was framed by two organizing dimensions, a content dimension and a cognitive dimension. The content dimension subsumes five content domains: life science, chemistry, physics, earth science, and environmental science, and consists of three cognitive domains: factual knowledge, conceptual understanding, and reasoning and analysis (Mullis et al., 2003).

The five content domains are described in more detail in Table 5.2 (below). Concepts related to matter and energy overlap considerably in both the physics and chemistry domain and Grade 4 does not separate them as opposed to Grade 8. Environmental science, as a field of applied science concerned with environmental and resource issues, involves concepts from the life, earth, and physical sciences.

Table 5.2 ***Science content domains and target percentage in TIMSS 2003 for Grade 8***

Domains	**Main topic areas**	**Target percentage devoted**
Life science	understanding of the nature, function of living organisms, the relationships between them, and their interaction with the environment	30%
Physics	general physical states of matter and their transformation	25%
Chemistry	the properties, composition, classification, and particular structure of matter	15%
Earth science	earth structure and physical features, the earth's processes, cycles and history, and the earth in the solar system and the universe	15%
Environmental science	changes in population, use and conservation of natural resources, and changes in environments	15%

Source: Adapted from Mullis et al., 2003

The cognitive dimension involves the sets of behaviour expected of students as they engage with the science content. This domain is divided into the three areas of factual knowledge, conceptual understanding, and reasoning and analysis (Mullis et al., 2003). *Factual knowledge* refers to students' knowledge base of relevant science facts, information, tools, and procedures. When students solve problems and develop explanations in science, accurate and broad-based factual knowledge enables them to engage successfully in doing, understanding, and interpreting science. Therefore, factual knowledge is a prerequisite to students' in-depth learning process. *Conceptual understanding* involves perceiving the relationships between the phenomena of the physical world and drawing more abstract or more general scientific concepts from the observations. It can be measured by the way students using and applying it perform specific tasks. *Reasoning and analysis* are related to the more complex tasks occurring in unfamiliar or more complicated contexts in which students should reason from scientific principles to provide an answer. The process of engaging with such tasks may involve a variety of approaches or strategies (Mullis et al., 2003). The details are described along with other student skills and abilities defining the cognitive domains in Table 5.3 (below).

Within the content and cognitive domains, scientific inquiry, which included knowledge, skills, and abilities as well as problem solving and inquiry tasks, was assessed overall in various content-related contexts. Identifying the impact of each of these factors is important since it can inform one of where education and learning can be improved.

Table 5.3 ***Science cognitive domains and target percentage in TIMSS 2003 for Grade 8***

Domains	**Main activities**	**Target percentage devoted**
Factual knowledge	Recall/recognize, define, describe, use tools & procedures	30%
Conceptual understanding	Illustrate with examples, compare/contrast/classify, represent/model, relate, extract/apply information, find solutions, explain	35%
Reasoning and analysis	Analyze/interpret/solve problems, integrate/synthesize, hypothesize/predict, design/plan, collect/analyze/interpret data, draw conclusions, generalize, evaluate, justify	35%

Source: Adapted from Mullis et al., 2003

It should however, be noted that a large-scale international assessment like TIMSS may not cover all the content taught in science in each country. Some of the topics tested in TIMSS 2003 may be part of other curricula, such as those for geography or social studies. This was the case with South Africa and, where the topic coverage was the lowest amongst the participating countries (Martin, Mullis, Gonzalez & Chrostowski, 2004).

Using the aforementioned framework, the development of the assessment items was effected through the cooperative efforts of the NRCs and the science task forces composed of the science coordinator and two experienced science item writers. Once the items were developed, they were reviewed by the task forces, and later by an Item Review Committee and a group of experts. Subsequently, the items reviewed were field-tested in participating countries and again reviewed by the Science and Mathematics Item Review Committee. Finally, the items were endorsed by the NRCs of the participating countries to ensure that the assessments represented the curricula of the participating countries and that the items exhibited no bias toward or against particular countries, along with an opportunity to match the content of the assessment to each specific country's curriculum (Martin, Mullis & Chrostowski, 2004).

The resulting TIMSS 2003 Grade 8 assessment contained 194 items in mathematics and 189 in science. In order to ensure broad subject-matter coverage without overburdening individual students, TIMSS used a matrix-sampling technique. Each assessment item was assigned to one of 14 mathematics or 14 science item blocks and these were distributed across 12 booklets. Each student took one booklet containing both mathematics and science items (Mullis et al., 2003). The science assessment at Grade 8 contained 109 multiple-choice and 80 constructed-response types where students were asked to generate and write their own answers. Among constructed-response questions, some asked for short answers while others required extended responses requiring students to offer explanations for their answers. Additionally, the assessment included 7 problem-solving and inquiry tasks for Grade 8, reflecting the importance placed by the assessment framework on problem-solving, reasoning and scientific inquiry (Martin, 2004).

In line with the purpose of TIMSS, the assessment encompassed items used in the 1995 and 1999 administrations to guarantee reliable measurement of trends over time. With this intention, 74 items in science and 79 items in mathematics, for both multiple-choice and constructed-response items, were trend items that had already been used in 1995 and 1999.

5.6.2 THE CONTEXTUAL QUESTIONNAIRES

TIMSS 2003 developed 11 questionnaires across the two grades and two subjects, with NRCs completing four. Grade-8 students who were tested answered questions pertaining to mathematics and science. The mathematics and science teachers of sampled students responded to questions about teaching. Questionnaires for mathematics and science teachers were administered separately at Grade 8. The principals responded to questions about schools at Grades 4 and 8 (Martin, Mullis, Gonzalez & Chrostowski, 2004). The purpose of the questionnaires was to gather information about five broad areas, viz., curriculum, school, teachers and their preparation, classroom activities and characteristics, and students at various levels of the educational system (Mullis et al., 2003). All questionnaires were based on Likert-type scales to record the self-reported information. Three questionnaires on student, science teacher, and principal were examined in the current study, and are described in more detail below.

Principal questionnaire: The school questionnaire addressed to the principal of each sampled school covered school-quality-related issues such as school organization, roles of the principal, and resources to support mathematics and science learning, parental involvement, and a disciplined school environment. Some of the main topics addressed in the school questionnaire were as follows: school climate, stability and mobility of the student body, parental involvement, professional development, instructional resources, and principal's experience (see Appendix D). The school questionnaire comprised 25 items and various sub-items that constituted item sets and was designed to be completed in about 30 minutes.

Science teacher questionnaire: The science teacher of the class tested was asked to complete a science teacher questionnaire. The questionnaire for teachers was composed of information about the classroom contexts for teaching and learning, and actually about the implemented curriculum in science. Teacher preparation and professional development, and the use of technology were newly added to the TIMSS 2003 teacher questionnaire. The main areas included teaching experience, preparation to teach, teacher interactions, attitudes toward subject, time spent teaching subject, content-related activities, factors limiting teaching, topic coverage, homework, and assessment (see Appendix C). The science teacher questionnaire was made up of 34 items, some of which consisted of various sub-items. The teacher questionnaire was designed to be completed within 45 minutes, reflecting the greater number of items.

Student questionnaire: Each student of the class sampled for the TIMSS 2003 study was asked to complete a student questionnaire, designed on the basis of factors thought to influence student achievement in science and so focusing on home background and resources for learning, prior experiences, and attitudes toward learning. The main question areas covered language, books in the home, home possessions, parents' education, educational expectations, liking and valuing science, learning activities in science, safety in school, out-of-school activities, and extra lessons or tutoring (see Appendix B). It comprised 23 items with some items including sub-categories. The TIMSS 2003 student questionnaire was designed to take about 30 minutes to complete. Across the aforementioned questionnaires, parallel questions were used to measure the same construct from different sources.

Since the instruments were developed in English, they were translated by the participating countries into 34 languages of instruction. The full set of instruments were translated into Korean for application in Korea, while the assessment in South Africa was contextualised for South Africa, adapted to international English and also translated into Afrikaans. The IEA Secretariat in Amsterdam used a rigorous process of translation verification to ensure that instruments and questionnaires were translated accurately and were internationally comparable (Martin, Mullis & Chrostowski, 2004).

5.7 DATA ANALYSIS

Data analysis began with exploring the TIMSS data sets to preliminarily identify sets of items and single items which relate to the factors of the conceptual framework. The constructs related to effective science education had already been defined when developing the conceptual framework in the previous chapters (3 and 4). First, the item examination was paralleled by descriptive statistics to get a brief view of the two countries' sets of data and to explore them for suitability for further analyses (5.7.1), with missing data also scrutinized (5.7.2). Next, the statistical processes such as factor and reliability analysis were used to build construct validity (5.8.3).

5.7.1 EXPLORING THE DATA SETS

In order to explore the data sets, the definition of the factor was compared to the contents of the items from the TIMSS questionnaires (see Appendix B, C, and D). The items which corresponded to the definitions were selected and recoded to suit the current study. The codes were reversed when an item was negatively phrased. Corresponding to the factors of the conceptual framework, variables were renamed, labels assigned to the codes given and measurement scale allocated. Once the data were recoded and checked for errors, the file was converted into a Statistical Package for the Social Sciences (SPSS) for further analysis.

Using the SPSS programme, the descriptive statistics analysis for the items was undertaken in order to describe, organise and make understandable data for the study (Minium, King & Bear, 1993). The descriptive statistics involved the identification of the mean, standard deviation, range of scores, skew and kurtosis. Frequencies were run for the selected items and the output was examined for any missing cases and values in the data, as well as the percentage of respondents who checked each answer option.

The evaluation of descriptive statistics, like running frequencies, shows the characteristics of the sample tested, and allows the researcher to check if the data violates any assumptions underlying the statistical techniques for further analysis and addresses specific research questions (Pallant, 2007). For instance, histograms generated from the descriptive statistics can provide a visual representation of the normality of the data. Usually parametric tests have four basic assumptions to ascertain the accuracy of the tests: normally distributed data, homogeneity of variance, interval data, and independence (Field, 2005). Since this particular research involved factor analysis and multilevel analysis to answer the research questions, it is important to check if any assumptions underlying those statistical techniques were violated. At the first stage of testing the assumptions, the research searches for missing case and data. Next, the distribution of scores is explored to check the normality. Apart from the information about the distribution of variables, the descriptive statistics provided the central tendency of the data, variability around the mean, deviations from normality, the spread of the distribution and information about stability or sampling error in the data.

The distribution of scores was explored by checking the skew and kurtosis. The skew indicates the symmetry of distribution, which is whether the data is normally distributed. A positive skew has scores clustered to the left of the centre while a negative skew indicates the reverse. The kurtosis indicates peaks of distribution, with a positive value of kurtosis having the peak of distribution in the centre and a negative value indicating a flat distribution (Field, 2005). A zero value of skew and kurtosis means that the distribution is normal, which rarely happens in the social sciences. A larger sample (more than 200 cases) tends to lessen the effects of skew and kurtosis. While the skewed distributions should be transformed so that the scores are normally distributed for further analysis, checking the shape of the distribution by means of a histogram is recommended in a large sample, since the tests used for skew and kurtosis are too sensitive for a large sample (Pallant, 2007). It should be borne in mind that violation of the assumption of normality is common in a larger sample, and skewed distributions reflect the underlying nature of the construct being measured, not a problem with the scale (Field, 2005).

The exploration of the data set also identifies outliers, cases with scores well above or well below the majority of other cases. Since the outliers influence mean and standard deviation as well as distribution (Field, 2005), there is a need to decide how to deal with the outliers by removing, transforming, or changing the value. If the mean and the trimmed mean values are very similar, the decision could be taken to include the outlier. If the outliers identified are the main cause of the skewed distribution, the transformation can reduce the impact as described above. Change to the scores, if transformation fails, can be made by the next highest score plus one, converting back from a z-score, or the mean plus two standard deviations (Field, 2005).

5.7.2 MISSING DATA

Generally, research shows three types of missing data, viz., missing completely at random (MCAR), missing at random (MAR), and missing not at random (MNAR) (Croninger & Douglas, 2005). It is understood that in a large-scale study like TIMSS, the pattern tends to include all these kinds of missing data. It was reported that there are many factors influencing the relative performance of most missing data procedures: sample size, number of variables missing, mechanism of missing data, proportion of missing data, average inter-correlation among variables, characteristics of the variables, and psychometric properties of the measures. Despite all these factors, the proportion and pattern of missing data are most likely to influence the relative performance of missing data procedures (Dodeen, 2003).

Some methods may be employed to deal with missing data in analysis. SPSS has two methods to deal with it, the *listwise method*, which deletes any case that has missing values and accordingly, it results in a loss of sample and statistical power; and *pairwise method*, which uses all the data available in an analysis and deletes the specific missing values from the analysis, generating different sample sizes for each parameter. Accordingly, it is practical when the sample size is small or missing values are large (Croninger & Douglas, 2005).

Another way to deal with missing values or data is to replace them through *imputation*, which includes *mean substitution*. Dodeen (2003) documented that valid mean substitution was more effective than multiple regression replacement in terms of producing parameters like R^2, the coefficient of determination, or F value. The favoured type of imputation is an estimation method such as *Full-Information Maximum Likelihood*, which is considered superior when missing data is non-random.

The study excluded missing cases prior to dealing with missing data (values) as the two countries had a large enough sample size, even after removing them. Thereafter missing data in each of the remaining cases was taken care of, being replaced by mean or median, given that the sample sizes in question were large in contrast to the amount of missing data at each level, and not so serious. It should be noted that this way is a very traditional approach, although it is documented that it would be acceptable to consult other sources of secondary analysis (Bos, 2002; Howie, 2002). If more than 5% of the data was missing for an item which seemed important for analysis, then it was replaced using the mode, mean or median. The mean was used where the distribution of frequency was not skewed, the median where the distribution of frequency was skewed, and the mode was used to replace missing data specifically for yes-no format items (Allison, 2002; O’Rourke, 2003; McKnight, McKnight, Sidani & Figueredo, 2007).

Once all missing data was replaced, as explained above, frequencies were run again and finally reviewed before proceeding, in order to ensure that the data was ready for further analysis and to construct scale scores.

5.7.3 CONSTRUCTING SCALE SCORES AND VARIABLES

A good instrument depends on internal consistency and unidimensionality of items constituting scales in nature (Gardner, 1995). Whereas internal consistency is commonly determined by calculating Cronbach alpha as put forward above, the unidemensionality of scales can be tested using a statistical technique such as factor analysis (Osborne et al., 2003). The study calculated reliability of a set consisting of more than three items in order to find internally consistent items. Once the sets were satisfied with reliability criterion (alpha=0.5), those items were then examined along with the results of factor analysis. Items finally extracted from the analyses were summed to make up a scale. The details are discussed as follows.

5.7.3.1 Factor analysis

Factor analysis is used to determine the underlying conceptual structure in a set of items (Coolidge, 2000). Since it is concerned with grouping together items that have the same construct, it can help researchers reduce a set of items to a smaller number of underlying factors, form a conceptually understood set of data, and ultimately ensure construct validity of the research (Cohen et al., 2007). There are two main forms of factor analyses, namely *exploratory* and *confirmatory*. In this study, exploratory factor analysis, also referred to as 'principal component analysis', was used, and involved exploring previously unidentified groupings of variables for underlying patterns (Cohen et al., 2007). The factor analysis (Devellis, 1991) was carried out in the following steps:

- It determined whether a set of items were suitable for factor analysis by investigating sample size and the strength of inter-item correlation. Correlation matrix from items was constructed in order to examine pure item homogeneity. The inter-item correlation for the optimal level of homogeneity should range from 0.2 to 0.4 (Briggs & Cheek, 1986). The research adopted the two other measures generated by SPSS, which are the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. The KMO index ranging from 0 to 1 should be at least 0.6 or above, and Barlett's Test of Sphericity should be significant (p<.05) (Pallant, 2007).

- Once the matrix was established, latent variables were identified by means of factor extraction, which explained the patterns of co-variation among items. The method of factor extraction refers to such different procedures as principal component analysis, principal axis factoring, and maximum likelihood. The current research used principal component analysis, which is the most commonly used analysis procedure. Research has shown that different procedures tend to yield similar solutions, regardless of which are used (Briggs & Cheek, 1986).

- First factors related to the most shared co-variation among items that best account for the total variance amongst the entire set were identified. Successively, other factors with the next most remaining co-variation amongst items were identified. The second factor is likely to account for less variance than the first. This process was continued as far as factors classified in the model were met. Factor loadings, which represent correlations between each item and a factor, were also generated and examined (Kline, 1993). The value of loading ranges from +1.00 to -1.00 and the higher absolute value indicates the stronger relationship (Crowl, 1986). For the purposes of this research, loadings of 0.3 and above were considered as acceptable (Kline, 1993).

- Even though factors are extracted as explained above, they are still arbitrary. By performing a factor rotation, one can make the picture of the relationships among the items simpler and clearer. Factor rotation identifies items with high factor loadings on one factor but low on the others, and draws a meaningful and understandable factor structure. There are various methods to rotate factors, such as *Varimax,* which involves the factors being orthogonal or independent, and *Direct Oblimin* and *Promax* which allow factors to correlate. Orthogonal rotation with *Varimax* rotation, where the independence of factors is sustained, was practised for simplicity in the study. *Varimax* rotation is considered useful to maximize the variance between factors and thus more likely to distinguish from each other (Cohen et al., 2007). As any factors to emerge would presumably be somewhat correlated, an oblique approach like *Direct Oblimin* would be more appropriate. As mentioned with the extraction method, the rotation method did not change the results in any meaningful way, regardless of variations (Briggs & Cheek, 1986).

- Finally, an approach known as *Kaiser's criterion* used the eigenvalue rule and scree test techniques to confirm the proper number of factors to retain. A minimum eigenvalue of 1 was utilized while *Catell's Scree* test was used and, as Catell recommends, all factors above the elbow or break in the plot are retained (Pallant, 2007). Additionally, parallel analysis could be used to compare the size of the eigenvalues with those derived from a randomly generated data set of the same size. Only those eigenvalues that exceed the corresponding values from the random data set are retained. Eigenvalues indicate how much variance a factor accounts for in terms of the average original variable. An eigenvalue of 1.0 indicates that a factor accounts for as much of the variance as the average original variable. However, since an eigenvalue greater than 1.0 is likely to result in overestimating the number of underlying factors, researchers tend to reject this procedure (Briggs & Cheek, 1986).

As explored up to this point, the study examined the internal structure of the many items of the TIMSS data of Korea and South Africa. As factor analyses identified latent variables underlying a set of items offered in TIMSS, and substantive meaning of the latent variables (DeVellis, 1991), the different results between the two countries mean underlying patterns on the variables sought are different (Cohen et al., 2007).

5.7.3.2 Reliability analysis

Reliability is concerned with consistency of scale, which is also referred to as stability and equivalence, over time, over samples, and over forms. As many items constitute a scale in the study, it assessed in particular the internal consistency of the scale prior to further analysis being made. Once items were confirmed as suitable constructs for the research by means of factor analysis, and problems identified as well as rectified where possible, the reliability analysis was carried out to examine internal consistency of the remaining items that made up the scales.

The degree of internal consistency reliability was calculated by Cronbach's coefficient alpha (α), which is most widely used for items that are not answered 'right' or 'wrong' but with a range of possible options (McMillan & Schumacher, 2006). The reliability coefficient ranges from 0.00 to 1, but where the coefficient of a scale is high, the scale is highly reliable, and vice versa. For the most part, 0.70 to 0.90 is acceptable (McMillan & Schumacher, 2006). DeVillis (1991) suggests a scale of 0.65 for questionnaire data. However, as this is an exploratory study, a coefficient as low as 0.5 for the questionnaire is considered acceptable (Bos, 2002; Howie, 2002). For achievement data, however, a coefficient above 0.8 is preferable (Kline, 1993).

Apart from considering Cronbach alpha values above 0.5, the mean inter-item correlation and the correlation between each item and the total score were also examined as another means of item homogeneity. A high item-total correlation would be expected if items measure the same construct, which then would contribute to the total score of a test (Kline, 1993). Furthermore, where the items comprising a scale have a strong relationship to a latent variable, they are likely to have a strong relationship within themselves as well (DeVellis, 1991). Therefore, high correlations between the items reflect strong links between the items and the latent variable and indirectly imply the internal consistency of the factor.

In the case where the number of items that make up a scale is as small as less than 10, the mean inter-item correlation for the items can be calculated and reported. The mean inter-item correlation values ranging from 0.2 to 0.4 were acceptable for the study (Briggs & Cheek, 1986). When a set of items has a correlation value of less than 0.25 between items and the total score, they were excluded from the research.

5.8 CORRELATION ANALYSIS

Once factor and reliability analyses confirmed the items are uni-dimensional and internally consistent, the scores were added together to make scales, and variable names and labels were assigned for further analysis. Thereafter, correlation analysis was undertaken to ascertain the relationship between the scales or factors identified. First, preliminary examination was made to ensure no violation of the assumptions of normality, linearity and homoscedasticity[9] occurred but not in a strict way as the study involves large sample and regression analyses in nature. Next, bivariate correlations calculated for the scales constructed using the items from the questionnaire and science achievement. The inter-correlations between the scales were also examined to ensure that multicollinearity[10] is not present in the data.

The study calculated a correlation coefficient, the bivariate Pearson product-moment correlation coefficient γ. The product-moment correlation has been known to be appropriate when both variables have continuous scales as in achievement tests or self-concept inventories (McMillan & Schumacher, 2006). Correlation coefficients range from -1.00 to +1.00 and indicate the strength and direction of a relationship. A plus sign indicates a positive relationship and a minus sign a negative one. Where the coefficient is below plus or minus 0.35,

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[9] Homoscedasticity indicates that the variance of the error terms for the independent variable is constant and one of assumptions in regression analysis (Miles & Shevlin, 2001).

[10] Multicollinearity exists where independent variables are highly correlated in regression analysis, (Mendenhall, & Sincich, 1996).

the relationship is low and an inference that the variables are not related can be drawn. Coefficients between plus or minus 0.35 and 0.65 indicate the variables are moderately related. When the coefficient is higher than plus or minus 0.65, the variables are highly related (Gay & Airasian, 2003).

The study adopted a correlation coefficient of an absolute value above 0.2 and the significance level, 0.01 (0.99, confidence interval) as criterion to include the scales for further analysis. The criterion for cut-off seems low, a slight relationship, considering the strength of a relationship to coefficient value described above. Nonetheless, when correlations are ranging from 0.20 to 0.35, and if the number of cases is more than 100, it may be statistically significant and valuable enough to explore the interconnection of variables in particular in explanatory studies such as this (Cohen et al., 2007; Cresswell, 2008). As for the significance level, the level of statistical significance of a correlation tends to depend largely on the sample size. The greater the sample size, the smaller the correlation needs to be in order to be significant at a given level of confidence (Cohen et al., 2007).

In some instances, variables were constructed from a number of items as a result of factor analyses and reliability analyses. However, in other instances and based on literature, single items were used as a variable, such as level of education of mothers and fathers. Once it is considered that the items make sense conceptually, those items were analyzed by correlation analysis as well. Although correlation analysis does not guarantee causal relationships, it enables one to preliminarily identify the causes of important educational outcomes and to predict the score on a dependent variable (McMillan & Schumacher, 2006).

In addition to correlation coefficients, the coefficient of determination and the significance level could be investigated through regression approach in the correlation analysis. The coefficient of determination can be calculated by squaring and multiplying the γ value by 100 to make a change into percentage of variance. It represents how much variance is shared. A correlation of 0.2 means that only 4% of the variance is shared, but it can not be ignored in large-sampled and exploratory studies (Cohen et al., 2007).

5.9 MULTILEVEL ANALYSIS

Multilevel analyses refers to any analysis that involves data sets with a nesting structure, such as students in classes, classes in schools, or schools in districts (Snijders & Bosker, 1999). Multilevel modelling has a hierarchical data set collected at all existing levels, but with one single outcome that is measured at the lowest level, namely student level. The term ‘multilevel regression model’, dealing with such multilevel data sets, is used interchangeably with ‘random coefficient model’, ‘hierarchical linear model’, or ‘variance component model’ (Hox, 2002).

Since TIMSS collected data in a multilevel structure, viz., student, classroom, and school, and the intact class in a school was sampled to allow data to be collected in a natural situation, effects of both individual and group level variables need to be taken into account (Keeves & Sellin, 1997). Multilevel analysis is recommended if research is to focus on correlations between levels as well as within levels, particularly as single level analysis dealing with aggregating data fails to explain within and across-level interaction or relation (Kyriakides & Charalambous, 2005). Kyriakides and Charalambous’s comparison between findings of single-level analysis and multilevel analysis into TIMSS 1999 data strongly supports a multilevel approach in analyzing the data of the IEA studies consisting of hierarchical structures.

5.9.1 CHARACTERISTICS OF MULTILEVEL ANALYSIS

The analysis of data, which is structured at several levels, is concerned with compositional effects across levels and takes account of grouping effects (Fitz-

Gibbon, 1996). More specifically, students are grouped in a classroom and again the classroom is nested within the next higher level, the school. Variables that influence student achievement exist at the student level, classroom, and school level respectively. When considering the structure of hierarchy in the data collected, students within a class tend to be more alike than those from different classes, and the same holds for the school level.

In terms of the variance effects, multilevel analysis makes it possible to understand where and how it occurs because it deals simultaneously with the variance components at all levels (Rasbash, Steele, Browne & Goldstein, 2009). It is considered that the ability to estimate between-group variation in an attempt to explain variation is a great strength of multilevel modelling. Ultimately, multilevel analysis is the way to discover the inference made about the variance among all schools, using the schools sampled. As a result, researchers can explain the pattern of variance occurring across the schools of the population in question (Rasbash et al., 2009).

In contrast, linear models used previously deal separately with the variance at each level of the hierarchy and cause problems such as aggregation bias or misestimated precision (Raudenbush & Bryk, 1997). Furthermore, ignoring clustering causes other technical problems, such as the underestimation of standard error of regression coefficient, which makes an incorrect inference about the effect of higher-level explanatory variables by interpreting the effect as being significant when not so (Rasbash et al., 2009).

When considering hierarchy of data collected, the interaction between variables characterizing individuals and variables characterizing groups should also be considered in research which is involved in individuals’ achievements (Hox, 2002). Multilevel analysis enables the researcher to investigate the interaction between factors within each level and interaction between levels. Accordingly, multilevel analyses provide researchers with a picture of the variance in achievement in the whole system and of the factors affecting it.

There are several concepts in multilevel analysis that should be kept in mind. The first concept to note is intra-class correlation, which measures the extent to which the achievements of students in the same school resemble each other as compared to those from students in different schools. The intra-class correlation, which indicates the similarity between students in the same school, can be measured by the proportion of school[11] level variance compared to the total residual variation that is attributed to differences between schools (Hox, 2002; Rasbash et al., 2009).

The second concept to consider is random and fixed coefficients that show up as parameters in the multilevel regression equation. Random coefficients operate as a probability function varying within a level in the regression equations. It includes intercept and slope coefficients. Fixed coefficients show up as regression coefficients that are deterministic in regression equations (Hox, 2002). Because fixed coefficients apply within-level, they are not assumed to vary across within-level. Multilevel analysis determines random and fixed coefficients in the regression equation along with residual errors to explain the variance between and within levels.

The third aspect to look at is cross-level interactions that involve interactions between explanatory variables from different levels. The interaction effects in the multilevel equations are formed by multiplying the scores for the variables from the different levels.

Finally, there are various estimation methods when estimating parameters in the multilevel regression equations. The techniques used include Maximum likelihood (ML), Generalized Least Squares, Generalized Estimating Equations, Bootstrapping, and Bayesian methods (Hox, 2002). ML estimates of the population parameters that maximize the probability of observing the actual data are mostly used because they are robust against mild violations of the assumptions, such as having non-normal errors. The ML method has two

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[11] TIMSS 2003 sampled only one class per school

different functions, such as Full Maximum Likelihood (FML) and Restricted Maximum Likelihood (RML). The current study used FML because it has some advantages over RML, particularly as computing the ML estimates is easier in FML. In addition, the regression coefficients are included in the likelihood function and thus overall the chi-square test based on the likelihood makes it possible to compare two models with different regression coefficients, whilst RML allows one to compare only differences in the variance components (Hox, 2002).

5.9.2 BUILDING THE MULTILEVEL REGRESSION MODEL

Once the factors were confirmed through factor, reliability, and correlation analyses, along with single items, these were used for further analyses, namely multilevel analyses. The factors influencing science achievement in the two countries are different, as shown in the results, and thus multilevel analysis used the different sets of selected latent variables. It is expected that estimating the pattern of variation in the underlying population of the two countries becomes possible, enabling the researcher to explain the pattern in terms of the general characteristics of schools in the two countries.

TIMSS sampled one class per school and although more than one teacher tends to teach one class in Korea, the data from class level and school level cannot be differentiated, unlike the case of more than two classes under a school from a perspective of multilevel analysis. Therefore, the current study modelled the data in a two-level structure, viz., student, and classroom/school level. The two-level model distinguishes the variance specifically explained at the student level and then the variance accounted for at the classroom/school level in light of science achievement, together with the interaction between the two levels.

The model was built starting from the intercept only or null model. The detailed procedures can be summarized as follows:

- Step 1 – building a null model (the intercept-only model) to estimate the total variance. Because there are no explanatory variables in the intercept-only model, random effects depending on the residual variances represent unexplained error variance (Hox, 2002). The intercept-only model gives an estimate of the intra-class correlation ρ and a benchmark value of the deviance, which is a measure of the degree of misfit between the model and the data. The equation of the model is as follows:

  $Yij = \gamma_{00} + u_{0j} + e_{ij}$

  Y_{ij} = dependent variable, science achievement in TIMSS 2003 in this case

  γ_{00} = intercept or regression coefficients, the expected value of the outcome variable when all explanatory variables have the value zero.

  u_{0j} = residual error at the classroom/school level

  e_{ij} = residual error at the student level (Hox, 2002)

- Step 2 – building a lower-level, student-level, model and adding a predictor to the null model one-by-one to examine the deviation in each case. Once the deviations produced by each model have been identified, the researcher can rank all variables in order of largest to smallest in deviation. That order is the reference when the individual variables are entered into the model as the equation of the model is built up extensively. Entering individual variables into the model, by the so-called ‘step up method’, ‘step-by-step’, or ‘forward steps upward from level-1 method’. When a variable added resulted in a significant effect, it was kept in the model. To evaluate whether a variable is significant or not, the Wald test referred to as the Z-test and was conducted and any change in the deviance was examined by making use of Chi-square if the variable contributes to the model (Hox, 2002). In this step, the improvement of the final model with all lower-level significant explanatory variables can be tested by computing the deviance gap between the final model of the lower-level and the null model. The equation of the model with student-level explanatory variables can be written as:

$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + u_{0j} + e_{ij}$

Where:

X_{pij} = the first-level explanatory variables

Subscript p = explanatory variables at the student level

- Step 3 – building a higher-level, classroom/school, model. All explanatory variables from the lower level to the higher-level were entered into the model. This allows one to examine whether the group-level explanatory variables explain between group variations in the dependent variable. In this step, one can test the improvement of the final model with all lower-level and higher-level explanatory variables significant by computing the difference of the deviance between the final model of the lower level and the final model of the higher level just as in the previous step. The models in steps 2 and 3 are called variance component models since the residual variance is divided into components corresponding to each level in the hierarchy (Hox, 2002; Rasbash et al., 2009). Variance component models assume the fixed regression slopes and the random regression intercept (Hox, 2002). The variance component model with classroom/school-level explanatory variables can be written as:

$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + u_{0j} + e_{ij}$

Where:

Z_{qj} = the classroom/school-level explanatory variables

Subscript q = explanatory variables at the classroom/school level

- Step 4 – building the full model by putting all the variables identified as significant into the model. The full model can be formulated by adding cross-level interactions between explanatory group level variables and those individual level explanatory variables that had significant slope variation above. The model built for the full steps is as follows:

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + \gamma_{pq}Z_{qj}X_{pij} + u_{pj}X_{pij} + u_{0j} + e_{ij}$$

Where:

$Z_{qj}X_{pij}$ = cross-level interaction term

u_{pj} = the classroom/school-level residual of the slopes of the student-level explanatory variables X_{pij}

The researcher started with fixed regression coefficients, as fixed parameters are more likely to be estimated with much more precision than random parameters (Hox, 2002). The random coefficient model can be built to see whether there exist the slopes of explanatory variables of which variance between the groups is significant. Testing for random slope variation on the basis of variable-by-variable might lead to an explanatory variable having no significant average regression slope but having a significant variance component in random coefficient model. After each process of adding explanatory variables, parameters added were examined to see if they are significant, as were the residual errors.

Estimation of parameters, including regression coefficients and variance components in the multilevel models, was mostly made by using the Full Maximum Likelihood (FML) method, referred to as Iterative Generalized Least Square (IGLS) in MLwiN (Hox, 1995). As put forward above, FML is preferred since IGLS is faster and numerically more stable, and the overall chi-square test based on the likelihood makes it possible to compare two models with different regression coefficients in FML and formally test the improvement of fit (Hox, 1995; Hox, 2002). Based on the results of FML, the decision was made as to which should be included in the model based on significance tests, the change in deviance and change in variance components (Hox, 2002).

5.9.3 PROGRAMMES OF THE MULTILEVEL REGRESSION MODEL

There are several kinds of programmes used for analyzing the multilevel regression model including HLM, VARCL, and MLwiN. HLM is considered the easiest to use and the output contains the parameter estimates, their standard errors, the covariance at the two levels, and the deviance. HLM provides *p*-value as an indicator for their significance. In contrast, VARCL does not provide *p*-value although using FML, comparing the deviance of different models, or inspecting the estimates and standard errors of various coefficients in one specific model. Hence, it should be computed outside the programme (Hox, 1995).

In addition to the various characteristics featured above, MLwiN contains more build-in provisions and is considered more difficult as such. MLwiN uses the single equation representation when the multilevel models are formulated while the software HLM specifies the separate equations at each available level (Hox, 1995). The single-equation formulation makes the effect of cross-level interactions clear. On the other hand, the single-equation representation hides the effects of the complicated error components as multilevel models have different slopes (Hox, 2002).

For the purpose of this research MLwiN, software developed by the Centre for Multilevel Modelling in the UK, was used. MLwiN has some interesting features. In terms of workplace, the programme has a graphic interface with plotting, diagnostics and data manipulation facilities. Besides, it is spreadsheet-typed which consists of columns and rows (Rasbash et al., 2009). On the other hand, it makes it possible an analysis of non-standard as well as standard multilevel models by allowing all regression coefficients to be random at all levels. In addition, researchers can analyse data with arbitrary levels and estimate FLM and RLM by MLwiN. Furthermore, MLwiN allows researchers to make repetitive computations and the use of residuals derived from analysis for another model.

Accordingly, it is a user-friendly help system in terms of data computations and manipulation. It however should be noted that MLwiN does not handle missing values and one has to deal with them as described in advance before importing them into the programme.

5.10 METHODOLOGICAL NORMS

To confirm the quality of the data and improve the generalisability of the results collected in survey research, reliability and validity need to be achieved. These can be explicated into several kinds respectively, depending on the goal of the research. In this study they were as follows:

5.10.1 VALIDITY CONSIDERATIONS FOR THE STUDY

An assessment's validity is the extent to which it measures what it claims to measure (Goldstein, 1993), property obtained at the end of research. Validity as a property can be expressed by degree (high, moderate or low) and inferred from evidence. Therefore, validity, which is mainly referred to as construct validity, is inextricably linked with the consequences of research involved in assessment or questionnaires. On the other hand, validity can be negatively influenced by inadequate sampling or administration and poorly-constructed items (Gronlund, 1998; Linn & Gronlund, 2000). Therefore, validity should be ensured in all areas of research.

There are different facets of validity which form part of the unitary term ‘validity’, such as content-related validity, construct-related validity, and predictive validity. TIMSS ensured in particular the content-related validity of instruments, which included face and content validity in the process of designing instruments (see Chapter 2). Despite various aspects of validity, Messick (1981) argues that construct validity takes precedence over other validities from both a scientific and applied point of view in education and psychology. Construct validity was addressed quantitatively by using inferential statistics such as factor analysis and reliability analysis (Suen, 1990). Factor analysis, in particular, is one of the most useful methods for studying and validating the internal structure of instruments (Schönrock-Adema, Heijne-Penninga, van Hell & Cohen-Schotanus, 2009). If the measurement of a scale is taken as measuring what it is supposed to measure, then the variance would be accounted for by a loading on a single factor (Osborne et al., 2003).

The current study focused specifically on construct validity with respect to the questionnaires by undertaking factor analyses and reliability analyses. The scores on the scales were grouped by the same construct, as items were clustered according to the conceptual framework for the study. From a perspective of the conceptual framework underlying the study, if some variables have to do with other constructs, the scales to measure those constructs can also be expected to have a similar bearing on the same constructs.

Construct validity ultimately leads to validity of inference and the consequence of the study (McMillan & Schumacher, 2006). Given that this research was based on an adapted conceptual framework, construct validity supported by the empirical evidence is important in interpreting the consequence of the research by using the conceptual framework as a lens.

5.10.2 RELIABILITY CONSIDERATIONS FOR THE STUDY

Reliability is a measure for the consistency of instruments (Cohen et al., 2007), involving *stability,* which indicates a consistent measure over time and over similar samples, and *equivalence,* which is the consistency of the results through similar design or researchers (Cohen et al., 2007). *Internal consistency* denotes the homogeneity of the items, that is, the degree to which those that make up a scale all measure the same underlying attribute (DeVellis, 1991).

There are several ways to evaluate reliability of measurements, including test-retest reliability, split-half reliability, and internal consistency reliability. Initially TIMSS enforced test reliability by using a matrix-sampling technique, ensured test-retest reliability by TIMSS 2003, including items used in the 1995 and 1999 assessments, and inter-rater reliability when scoring the constructed responses at the data collection stage.

The study stressed internal consistency as it is useful for multi-item scales and thus considered a pre-requisite for construct validity to be established in building a scale based on multiple-items. Cronbach's coefficient alpha (α) is the most commonly used statistic for internal consistency reliability (Litwin, 1995), and is discussed further under the data analysis sections with the criterion of reliability (alpha=0.5) that are applied in the study (Howie, 2002).

5.11 ETHICAL CONSIDERATIONS

TIMSS 2003 makes available data from over 360,000 students, approximately 25,000 teachers, approximately 12,000 school principals, and the NRCs of each country, which aims at improving mathematics and science education by means of secondary analyses of the data. As part of the ethical considerations of the IEA, NRCs were requested to obtain permission from the respective Ministries of Education and from the schools and other stakeholders to release the data from all participating countries (Martin, 2005). This was done, and permission from the stakeholders was received. As part of the informed consent, anonymity and confidentiality of participants were guaranteed through the whole research process. Normally, as part of secondary analysis, free and informed consent is required to conduct a secondary data analysis. However, as the secondary analysis suggested here falls within the scope of the original consent, this is not deemed necessary.

5.12 CONCLUSION

In this chapter, the information concerning the research design and method was detailed. The intention of the current research was to explore factors influencing science achievement in two countries using quantitative data. Post-positivism grounded the current research, given that it researches the characteristics of relationships in educational contexts other than physical environment. The research also was categorized within secondary analysis in terms of method. The research used the TIMSS 2003 data set that collected by the IEA. The secondary analysis using the TIMSS data was recommended, considering that the data is of high quality, and researchers can save time and cost.

A description of the design issue, such as sampling and data collection, was described briefly and the instruments and methodological norms examined. Aspects of sampling, data collection, instrument, and methodological norms were explored, mainly consulting IEA's report on TIMSS, since the research is secondary analysis.

Data analysis strategies also were discussed. Firstly, the contents of the items from the TIMSS background questionnaires were explored to see the brief pictures in science education in the two countries. Corresponding to the factors of the conceptual framework, variables were identified, labels renamed to the codes given, and measurement scale assigned. Once the data were recoded and checked for any errors, the descriptive statistics was carried out by running SPSS. In particular, frequencies were run for the selected items and the output was examined for any missing cases and values in the data, as well as the percentage of learners who checked each answer option.

Factor analysis was undertaken of the items identified above that comprised sets of items. Extraction of factors made it possible to identify latent variables that can explain the patterns of co-variation among items. Thereafter, performing a factor rotation made the picture of the relationships among the items much simpler and clearer. In order to confirm the proper number of factors to retain, as Kaiser’ criterion the eigenvalue rule and scree test techniques were adopted. Besides factor and reliability analyses were undertaken to confirm whether the items can form the basis for the constructs or variables to be used in the further analyses or not. Correlation analyses followed them to see if items selected or scales made have a significant relationship with achievement.

With factors confirmed for further analysis through factor, reliability, and correlation analyses, the researcher carried out multilevel analyses that involve data sets with a nesting structure such as students in classes. Multilevel modelling can be adopted in the case of a hierarchical data set collected at all existing levels but with one single outcome at the lowest level. It is recommended to undertake multilevel analysis using IEA studies such as TIMSS due to their hierarchically-structured data. In the current study, multilevel analysis was carried out into the two different sets of selected latent variables, since the research showed that the factors influencing science achievement in the two countries are different.

How to build a two-level model, viz., student, and classroom/school level, was elaborated on. The null model or intercept only model which does not include any explanatory variables was explained. Thereafter, how variance component models were established at the lower and higher level was elaborated on. Lastly, the full model was described, including adding cross-level interactions between explanatory group level variables and those individual level explanatory variables. MLwiN, which was used in the research, was discussed in addition to the ethical considerations.

CHAPTER 6

DESCRIPTIVE ANALYSES

6.1 INTRODUCTION

In this chapter, results of exploratory analysis of the TIMSS data sets from Korea and South Africa are presented. The exploratory analysis focuses on how comparable science education is in both countries by examining the contextual information data. The data drawn from the TIMSS 2003 background questionnaires was analysed closely, corresponding to descriptive statistics. The exploratory analyses here are significant in terms of description but not explanation of contextual information provided in TIMSS data sets. Description and explanation are different in terms of level of understanding. *To describe* is to draw a picture about what something is like, while *to explain* means to account for why it is as well as what it is like (Punch, 2009). Therefore, this chapter focused on the case in Korea and South Africa respectively, with the reasons behind the events is explored in Chapter 7, including the results of factor, reliability, and correlation analyses.

As a first step towards explanation, the chapter begins with TIMSS 2003 science achievement scores for Korea and for South Africa in Section 6.2. The wide gap between science achievements across the two countries is highlighted. The differences between student achievements in the two countries imply the different contextual background for each country, the contextual backgrounds having been represented in Section 6.3. Background information based on descriptive statistics was specified corresponding to student, classroom/teacher, and school/principal levels. Lastly, a conclusion is drawn in Section 6.4.

6.2 TIMSS SCIENCE ACHIEVEMENT SCORES IN KOREA AND SOUTH AFRICA

The two countries in question scored differently on the TIMSS science test. The weighted means of the student scores on the international TIMSS science test are presented in Table 6.1 (below). The scores were standardized with a mean of 500 and a standard deviation of 100. Korean students scored an average of 558 (1.6) while South African students achieved an average score of 244 (6.7). The differences in the average mean scores highlight the enormous gap in achievement in science of the two countries. The research should ascertain where this gap was and how it occurred, in order to answer the research questions.

Table 6.1 also indicates the number of students, science teachers, and schools tested. Although one intact classroom per school was sampled, many more teachers were sampled in Korea compared to schools sampled. Even though there is an integrated science curriculum in Korean schools, at the school level science teachers prefer to teach one or two major fields from this curriculum, which could include Physics, Chemistry, Earth Science, or Biology. For that reason, a class in each Korean school is likely to have more than one science teacher. However, one science teacher is likely to be assigned for a class with an integrated science curriculum in South Africa.

Table 6.1 ***Descriptive data for Korea and South Africa***

Country	**Number of students**	**Number of teachers**	**Number of schools**	**Science achievement**	
				Mean	SD
Korea	5,309	357	149	558	1.6
South Africa	8,952	255	255	244	6.7

6.3 EXPLORING THE DATA SETS

In this section, an overview of descriptive statistics and an overall picture of the data are presented for the two countries, prior to starting in-depth analyses by looking at the results of the descriptive statistics. This helped the researcher to familiarise herself with the data, and understand its structure and identify, where possible, pitfalls such as data that is not normally distributed, missing data, and more than 5% variations in the data that would potentially influence the choice of statistics applied.

6.3.1 STUDENT LEVEL

Frequencies in SPSS were run on the item level first to get an overview of items which could play an important role in the achievement of pupils in the two countries. These items include speaking the language of the test at home and being in possession of books and educational equipment. Specifically, 99% of Korean students tested always or almost always spoke the language of the test at home, in contrast to only 27% of South African students tested who always or almost always spoke the language of the test at home, as shown in Table 6.2 (below). Research indicates that speaking the test language at home correlates strongly with achievement, and this is particularly evident in the achievement of South African students (Howie, 2002).

Table 6.2 ***Often speak language of test at home***

		N	Always	Almost always	Sometimes	Never
% of students	Korea	4872	71(0.8)	28(0.8)	1(0.2)	0(0.0)
	South Africa	6680	18(1.7)	9(0.7)	57(1.7)	15(1.0)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

Possessions such as books in the home and educational equipment also play a role in pupil achievement. The data revealed that 74% of Korean students tested had more than 26 books at home compared to only 25% of South African students tested (see Table 6.3, below).

Table 6.3 ***Number of books in your home***

		N	0-10 books	11-25 books	26-100 books	101-200 books	More 200 books
% of students	Korea	4873	15(0.7)	10(0.6)	33(0.8)	22(0.7)	19(0.8)
	South Africa	6573	44(1.3)	31(0.9)	14(0.7)	5(0.4)	6(0.5)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

Looking at other representative home possession, 97% of Korean students have a calculator, a computer, a study desk, and a dictionary at home, as opposed to the comparatively few South African students possessing these items (Table 6.4).

Table 6.4 ***Home possession***

		Calculator	Computer	Study desk	Dictionary
% of students	Korea	97(0.2)	98(0.2)	97(0.2)	99(0.1)
	South Africa	77(0.5)	36(0.6)	58(0.6)	70(0.6)

Note: () Standard errors.

Parents' educational level is another construct to consider, as discussed in Chapter 3. Only 11% of South African parents completed a first degree in contrast to 35% of Korean parents (Table 6.5, below). In literature, a significant relationship exists between the education level of parents and the achievement of their children (Von Secker, 2004). Within the two countries the education level of the mother is more important in South Africa, in comparison to the education level of the father's being more important in Korea (see Section 7.4).

Despite the importance of parents' educational level, as the South African data showed, more than 30% missing value in respect to parents' education level. These items were excluded from the further analysis.

Table 6.5 ***Highest educational level of parents***

		Finished university or equivalent or higher	Finished post-secondary vocational /technical education but not university	Finished upper secondary schooling	Finished lower secondary schooling	No more than primary schooling
% of students	Korea	35(1.2)	15(0.6)	41(1.0)	6(0.4)	3(0.4)
	South Africa	11(1.0)	13(0.7)	30(0.9)	18(0.7)	28(1.1).

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

As seen in Table 6.6 (below), students' educational expectations towards higher education are much higher in Korea (78%) than in South Africa (31%) which, as explored in Chapter 1, indicates Korean comparative enthusiasm for higher education. As was the case with parental educational level, students' educational expectations in South Africa were not retained for further discussion due to a high percentage of missing data.

Table 6.6 ***Students' educational aspirations***

		Finish university or higher	Finish upper secondary schooling	Finish lower secondary schooling	Finish primary schooling	I don't know
% of students	Korea	78(0.6)	6(0.3)	4(0.3)	2(0.2)	10(0.1)
	South Africa	32(0.6)	13(0.4)	9(0.4)	31(0.6)	15(0.5)

Note: () Standard errors.

TIMSS 2003 reported students' attitudes towards science by means of index (see Tables 6.7 and 6.8). The index of self-confidence in learning science was based on students' responses to four statements about science:

1) I usually do well in science
2) Science is more difficult for me than for many of my classmates
3) Science is not one of my strengths
4) I learn things quickly in science.

The index of valuing science was based on students' responses to seven statements about science:

1) I would like to take more science in school
2) I enjoy learning science
3) I think learning science will help me in my daily life
4) I need science to learn other school subjects
5) I need to do well in science to get into the university of my choice
6) I would like a job that involved using science
7) I need to do well in science to get the job I want.

Where students agreed a little or a lot on average across the four statements (seven statements for valuing science), they were assigned to the high level. When students disagreed a little or a lot on average, they were assigned to the low level. All other students were assigned to the middle level (Martin, Mullis, Gonzalez & Chrostowski, 2004).

Table 6.7 ***Index of students' self-confidence in learning science (SCS)***

		High SCS	Medium SCS	Low SCS
% of student	Korea	20(0.7)	42(0.7)	38(0.9)
	South Africa	45(1.1)	46(1.0)	9(0.4)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

Overall, South African students tend to have a positive attitude towards science in contrast to the result which reveals that Korean students tend to display a negative attitude (Tables 6.7 and 6.8). It should be noted that this attitude is not referred to on the individual level, but on the country level. Shen and Tam (2008) argue that the negative attitudes towards subjects in the country level may reflect high academic standards in high-performing countries, and vice versa. Similarly, the Korean students' negative attitudes towards science may reflect an attitude towards study and this can be explained by the reality that parents push their children to study hard to enter prestigious universities, as discussed in Chapter 1.

Table 6.8 ***Index of students' valuing science (SVS)***

		High SVS	Medium SVS	Low SVS
% of student	Korea	19(0.7)	55(0.7)	26(0.8)
	South Africa	76(0.9)	19(0.7)	5(0.4)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

In terms of classroom practice (see Table 6.9, below), listening to a lecture-style lesson is the most likely to occur in both Korea (81%) and South Africa (82%), although science lessons can consist of many formats. Korean students reported group experiment (39%), writing explanations of what and why (45%), and working problems on their own (59%) as common practice in science classes. In contrast, South African students reported reviewing homework (81%), presenting their work to the class (78%), and relating what is learnt in class to daily life (77%) as common practice in their science classes.

Table 6.9 ***Students' reports on classroom practice***

	% of doing the activity about half of the lessons or more													
	Watch the teacher demonstrate an experiment or investigation	Formulate hypotheses or predictions to be tested	Design or plan an experiment or investigation	Conduct an experiment or investigation	Work in small groups on an experiment or investigation	Write explanations about what was observed and why it happened	Study the impact of technology on society	Relate what we are learning in science to our daily lives	Present our work to the class	Review our homework	Listen to the teacher give a lecture-style presentation	Work problems on our own	Begin our homework in class	Have a quiz or test
Korea	32(0.7)	17(0.5)	15(0.5)	21(0.7)	39(0.7)	45(0.7)	22(0.6)	37(0.7)	17(0.5)	37(0.7)	81(0.6)	59(0.7)	8(0.4)	21(0.6)
South Africa	72(0.6)	65(0.6)	65(0.6)	64(0.6)	71(0.6)	72(0.6)	69(0.6)	77(0.5)	78(0.5)	81(0.5)	82(0.5)	61(0.6)	57(0.6)	70(0.6)

Note: () Standard errors.

Most Korean students (99%) used a computer, while 68% of South African students reported so and 25% had never used it (see Table 6.10, below). Korean students mostly used computers at home (97%, 0.2) while South African students mostly used them at school (48%, 0.7).

Table 6.10 ***Have you ever used a computer?***

		Korea	South Africa
N		5309	6784
% of students	yes	99 (0.1)	68 (0.6)
	no	1 (0.1)	25 (0.5)

Note: () Standard errors.

The results on school climate revealed that South African students have more positive attitudes towards school compared to Korean, as shown in Table 6.11:

Table 6.11 ***Students' agreement on school climate***

		Like being school	Try to do their best	Teachers care about students	Teachers want students to do their best
% of students	Korea	72(0.6)	63(0.7)	68(0.7)	95(0.3)
	South Africa	93(0.3)	88(0.4)	88(0.4)	90(0.4)

Note: () Standard errors.

UNICEF (2000) proposed safety environment to children as one of the basic dimensions of quality education. Most Korean students perceived that school was safe, unlike South African students where only a few felt the same way:

Table 6.12 ***Student experiences on school safety***

		Something of mine was stolen	I was hit or hurt by other students	I was made to do things I didn't want	I was made fun of or called names	I was left out of activities by other students
% of students	Korea	24(0.6)	9(0.4)	12(0.5)	16(0.5)	2(0.2)
	South Africa	50(0.6)	33(0.6)	39(0.6)	52(0.6)	38(0.6)

Note: () Standard errors.

With respect to out-of-school activities (see Table 6.13, below), South African students are more likely to spend time playing sports or with friends, while Korean students undertake computer-related activities such as playing computer games or accessing the Internet.

Table 6.13 ***Out-of-school activities***

	Average hours spent each day							
	Watch TV & videos	Play computer games	Play or talk with friends	Do jobs at home	Play sports	Read a books for enjoyment	Use the internet	Work at a paid job
Korea	1.7(0.03)	1.5(0.03)	1.8(0.03)	0.7(0.01)	0.7(0.02)	0.6(0.01)	1.7(0.03)	0.1(0.01)
South Africa	1.5(0.03)	0.7(0.02)	2.0(0.03)	1.8(0.03)	1.6(0.02)	1.6(0.03)	0.8(0.02)	0.8(0.02)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

In terms of time on task or opportunity to learn, extra tutoring has shown an important relationship with student achievement, as reviewed in Chapter 3. As shown in Table 6.14 (below), more students in Korea (58%) take extra tutoring in science at least once a week, as opposed to 46% of South African students tested. In particular, the percentage of students who take extra tutoring in science 'every or almost every day' is much higher in Korea (36%) than in South Africa (25%).

Table 6.14 ***Frequency of extra science lessons***

		Every or almost every day	Once or twice a week	Sometimes	Never or almost
% of students	Korea	36 (0.01)	19 (0.01)	5(0.0)	40 (0.01)
	South Africa	25 (0.01)	21 (0.01)	30 (0.01)	24 (0.01)

Note: () Standard errors.

In terms of ethnicity, most Korean students were born in Korea and have grown up in this country, as shown in Table 6.15 (below). In contrast, some 67% of South African students were born in South Africa, which means the rest of the population (33%) are immigrants.

Table 6.15 ***Country of birth***

	Korea	South Africa
N	4865	8393
% of students	99(0.1)	67(0.5)

Note: () Standard errors.

6.3.2 CLASSROOM LEVEL

Taking a closer look at the frequencies regarding teacher background, there are a greater number of younger, less experienced male science teachers in South Africa than in Korea (Table 6.16, below). More specifically, 56% of teachers are under 39 years old in Korea, compared to 75% in South Africa. In terms of gender, South African schools are balanced, while Korean schools have many more female science teachers. Overall, South African science teachers see themselves as being under-prepared to teach, in contrast to Korean teachers who seem to be more educated and are trained to become science teachers.

Table 6.16 ***Science teachers' characteristics***

		Gender		age				Have full certificate*	Number of years of teaching
		female	male	29 years or under	30-39 years	40-49 years	50 years or older		
% of students$^{\$}$	Korea	66(3.4)	34(3.4)	15(2.6)	41(3.0)	40(3.6)	4(1.7)	99(0.2)	13(0.5)
	South Africa	49(4.1)	51(4.1)	24(3.2)	51(3.4)	20(2.8)	4(1.2)	53(4.4)	10(0.5)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.
** does not include provisional or emergence certificate.*
$^{\$}$ % of students whose science teacher responded

As for teacher qualification (see Table 6.17, below), some 28% of students sampled were taught by South African teachers tested who had finished university, as opposed to 100% of Korean teachers tested. Completing four years at university is compulsory for becoming a secondary school teacher in Korea. In contrast, completing post-secondary education satisfies the requirement of teacher qualification in South Africa.

Table 6.17 ***Highest educational level of science teachers***

		Beyond university degree	Finished university or equivalent	Finished post secondary education but not university	Finished upper secondary schooling	Did not complete upper secondary schooling
% of students$^{\$}$	Korea	25(2.9)	75(2.9)	0(0.0)	0(0.0)	0(0.0)
	South Africa	7(2.0)	21(3.0)	69(3.5)	2(1.2)	0(0.1)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.
$^{\$}$ *% of students whose science teacher responded*

With respect to attitudes towards the subject of science (see Table 6.18, below), teachers in both countries strongly agree that teaching science should include:

- using more than one representation (98% in Korea, 95% in South Africa)
- solving science problems by hypothesizing, estimating, etc. (84% in Korea, 93% in South Africa)
- conducting scientific investigation by many ways (98% in Korea, 97% in South Africa)
- scientific theories changeable (95% in Korea , 78% in South Africa)
- modelling natural phenomena (76% in Korea , 92% in South Africa)

Both did not agree that science

- mainly involves memorizing (19% in Korea, 15% in South Africa)
- most scientific discoveries have no practical value (4% in Korea, 10% in South Africa)

However, there are some differences between the two countries. Most Korean science teachers tested disagreed that ‘getting the correct answer is the main focus in an experiment’ in contrast with the 55% of South African teachers tested who agreed with this belief. In addition, most South African teachers tested agreed that science teaching should be ‘primarily for obtaining skill and knowledge’ (88%). In contrast, just half of Korean teachers (51%) only agreed, with the rest disagreeing. South African teachers are more like to focus on scientific fact than scientific process.

Table 6.18 ***Teachers' attitudes toward science***

	The percentage of agreement with the statements below∮								
	More than one representation should be used in teaching a science topic	Solving science problems involves hypothesizing, estimating, testing, and modifying findings	Learning science mainly involves memorizing	There are many ways to conduct scientific investigation	Getting the correct answer is the most important outcome of a student’s scientific experiment	Scientific theories are subject to change	Science is taught primarily to give students the skills and knowledge to explain natural phenomena	Modeling natural phenomena is essential to teaching science	Most scientific discoveries have no practical value
Korea	98(0.9)	84(2.3)	19(2.5)	98(0.9)	8(1.7)	95(1.4)	51(3.1)	76(2.7)	4(1.2)
South Africa	95(1.6)	93(1.8)	15(2.6)	97(1.2)	55(3.6)	78(3.0)	88(2.3)	92(2.0)	10(2.2)

Note: () Standard errors.

∮The percentage of agreement includes options, ‘agree a lot’ and ‘agree’

Korean teachers tested (73%) are more likely to think that their schools are situated in a safe neighbourhood and thus they feel safe and secure at school (see Table 6.19, below). Korean teachers (62%) are less likely than South African teachers tested (81%) to think that their schools need major repairs. In contrast, fewer South African teachers (34%) agreed with the security policies and practices of their school than Korean teachers tested (66%). A classroom in Korea ranges from 20 to 48 students whereas South African classrooms consist of seven to 95.

Table 6.19 ***Teachers' perception of safety in the schools***

	The percentage of agreement with the statements below∮			
	This school facility is in need of significant repair	This school is located in a safe neighborhood	I feel safe at this school	This school's security policies and practices are sufficient
Korea	62(3.0)	73(2.8)	80(2.5)	66(3.0)
South Africa	81(2.8)	52(3.6)	52(3.6)	34(3.4)

Note: () Standard errors.

∮The percentage of agreement includes options, 'agree a lot' and 'agree'

With respect to content-related activities, there are some differences of interest between the two countries. As shown in Table 6.20 (below), South African teachers tend to ask their students to design or plan experiments, work in small groups, put events or objects in order, write explanations of what and why, study the impact of technology on society, and present their work to the class more often than their Korean counterparts. Both Korean (64%) and South African (78%) teachers seem to emphasize an activity such as 'relate what is being learned in science to our daily lives'.

Table 6.20 ***Teachers' reports on classroom practice***

	% of doing the activity about half of the lessons or more										
	Watch the me demonstrate an experiment or investigation	Formulate hypotheses or predictions to be tested	Design or plan an an experiment or investigation	Conduct an experiment or investigation	Work in small groups on an experiment or investigation	Write explanations about what was observed and why it happened	Put events or objects in order and give a reason for the organization	Study the impact of technology on society	Learn about the nature of science and inquiry	Relate what is being learned in science to our daily lives	Present their work to the class
Korea	32(2.9)	38(3.1)	19(2.5)	32(2.9)	27(2.8)	38(3.1)	24(2.7)	17(2.4)	31(2.9)	64(3.0)	31(2.9)
South Africa	27(3.2)	33(3.4)	41(3.6)	36(3.5)	58(3.6)	54(3.7)	41(3.6)	32(3.4)	47(3.6)	78(3.0)	56(3.6)

Note: () Standard errors.

Regarding factors limiting teaching science, fewer Korean teachers tested overall answered the ‘a lot’ option than South African teachers, as compared in Table 6.21 (below). Specifically speaking, with respect to student-related factors, Korean teachers are more likely to choose disruptive students (11%) as the strongest limiting factor as opposed to South African teachers choosing students from a wide range of backgrounds (26%).

Table 6.21 ***Limitations on instruction due to student factors***

	% of an option ‘a lot’ chosen					
	Students with different academic abilities	Students who come from a wide range Of backgrounds	Students with special needs	Uninterested students	Low morale among students	Disruptive students
Korea	6(1.5)	4(1.2)	4(1.2)	7(1.6)	9(1.8)	11(2.0)
South Africa	24(3.1)	26(3.2)	13(2.4)	21(3.0)	17(2.7)	18(2.8)

Note: () Standard errors.

Related to resource factors, Korean teachers chose high student/teacher ratio (14%) as the most limiting factor, whilst South African teachers responded that using computer-related resources was mostly limited and thus the ‘a lot’ was more than 50% respectively, as shown in Table 6.22:

Table 6.22 ***Limitations on instruction due to resource factors***

	% of an option ‘a lot’ shortage							
	computer hardware	computer software	Support for using computers	Textbooks for student use	Other instructional equipment for students’ use	Equipment for your use in demonstrations	Inadequate physical facilities	High student/teacher ratio
Korea	4(1.2)	4(1.2)	5(1.4)	2(0.9)	2(0.9)	3(1.1)	6(1.5)	14(2.2)
South Africa	56(3.6)	56(3.6)	55(3.7)	34(3.5)	46(3.6)	48(3.7)	48(3.7)	50(3.7)

Note: () Standard errors.

On topic coverage, South Africa was reported as one of the countries where fewer than half of the topics covered in TIMSS 2003 were included in its eighth-grade curriculum (48%). As seen in Table 6.23 (below), only 16% of the 48% of topic coverage was reported for all or almost all students with 32% being reported for students who were more able (Martin, Mullis, Gonzalez & Chrostowski, 2004). TIMSS documented that having at least moderate coverage of the science topics is a prerequisite for high performance although high coverage in the intended curriculum does not of itself lead to high student achievement (Martin, Mullis, Gonzalez & Chrostowski, 2004). TIMSS also reported that there is a moderately positive relationship between inclusion in the intended curriculum and student achievement. For example, top performing countries such as Singapore or Japan had about 70% of the science topics in their intended curricula in TIMSS 2003. Exceptionally, Korea, although among top-performing countries, had only 52% of topic coverage (Martin, Mullis, Gonzalez & Chrostowski, 2004).

Table 6.23 ***TIMSS science topic coverage in the intended curriculum***

	% of TIMSS science topics intended to be taught up to and including Grade 8		
	Topics for all or almost all students	Topics for only the more able students	Not included in the curriculum through Grade 8
Korea	52	0	48
South Africa	16	32	52

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.

Most teachers in both countries give students homework but in South Africa homework is reported to be given more often and more time is taken in completing it, as shown in Tables 6.24 and 6.25. South African students also reported the same way.

Table 6.24 ***Frequency of science homework***

		Every or almost every lesson	About half the lessons	Some lessons
% of teachers	Korea	9(1.9)	17(2.5)	74(2.9)
	South Africa	30(3.4)	25(3.2)	45(3.7)

Note: () Standard errors.

Homework is seen a good way to increase ‘time on task’ or ‘opportunity to learn’. As mentioned in Chapter 1 and shown in Table 6.14 at the student level, many Korean students take extra tutoring after school and Korean teachers tend not to give much homework as it might be an extra burden on students.

Table 6.25 ***Time assigned for homework***

		Fewer than 15 minutes	15-30 minutes	31-60 minutes	61-90 minutes	More than 90 minutes
% of teachers	Korea	19(2.6)	56(3.3)	22(2.8)	2(0.9)	1(0.7)
	South Africa	7(1.9)	56(3.7)	26(3.3)	4(1.5)	7(1.9)

Note: () Standard errors.

As expected from the high percentage of frequency and time on science homework in Tables 6.24 and 6.25, South African teachers are more likely to monitor and use homework in lessons in many ways than Korean teachers (Table 6.26. below). The results concur with the classroom practice reported by students as shown in Table 6.9 (above).

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Table 6.26 ***Use of homework***

		% of teachers who use always or almost always				
		Monitor whether or not the homework was completed	Correct assignments and then give feedback to students	Have students correct their own homework in class	Use the homework as a basis for class discussion	Use the homework to contribute towards students' grades or marks
% of teachers	Korea	59(3.3)	15(2.4)	16(2.5)	8(1.8)	31(3.1)
	South Africa	89(2.3)	82(2.8)	25(3.2)	34(3.5)	38(3.6)

Note: () Standard errors.

In regards to testing or assessing (see Table 6.27, below), it is significant that almost fifty percent of Korean teachers tested (49%) responded that they addressed testing every two weeks or less. Judging from the researcher's experience in Korean schools, their response might include either students' portfolios that are graded and summed up to students' scores or formative assessment that might occur in every class. South African teachers tested mostly preferred about half constructed-response and half multiple-choice formats (73%), while Korean teacher tested were likely to use mostly a multiple-choice format (70%) (Table 6.28).

Table 6.27 ***Frequency of science tests***

		Every two weeks or less	About once a month	A few times a year or less
% of teachers	Korea	49(3.2)	37(3.1)	14(2.2)
	South Africa	24(3.1)	63(3.5)	13(2.5)

Note: () Standard errors.

Recently, the policy in Korea encourages teachers to increase constructed-response format and decrease multiple-choice format as constructed-response formats are proved to facilitate higher-order thinking ability.

Table 6.28 ***Item formats used by teachers in science test or examinations***

		Only or mostly constructed-response	About half constructed-response and half multiple-choice	Only or mostly multiple-choice
% of teachers	Korea	10(1.9)	20(2.5)	70(2.9)
	South Africa	17(2.7)	73(3.2)	10(2.2)

Note: () Standard errors.

6.3.3 SCHOOL LEVEL

Even a rough look of the data at the school level shows some differences between the two countries that are worth discussing. Firstly, as for community size where schools are located, more than 80% of Korean schools (83%, 3.2) tested are located in cities whose population is more than 50,000. In contrast, only 35% (3.4) of South African schools tested are so.

From a perspective of stability of student body, Korean schools seem to be more stable than South African schools, as shown in Table 6.29 (below). Specifically, most Korean schools tested (99%) had fewer than 5% of their students absent, in contrast to 62% in South Africa. In addition, all Korean schools tested reported that the students in their schools had still been enrolled since the start of the school year. This, by contrast, was the case in only 59% of schools tested in South Africa.

Table 6.29 ***Mobility and stability of student body***

		Less than 5% of students absent from school	More than 96% of students still enrolled since the start
% of schools	Korea	99(0.9)	100(0.0)
	South Africa	62(3.4)	59(3.5)

Note: () Standard errors.

In light of student achievement, demographic characteristics, including student economic background is considered an important factor, as reviewed in Chapter 3. Almost 86% of schools tested in South Africa stated that more than 50% of their students came from economically disadvantaged homes, as opposed to only 10% in Korea, as shown in Table 6.30.

Table 6.30 ***The percentage of students in their schools coming from economically disadvantaged homes***

		0-10 %	11-25%	26-50%	More than 50%
% of schools	Korea	32(4.1)	41(4.3)	17(3.3)	10(2.6)
	South Africa	4(1.4)	3(1.2)	7(1.8)	86(2.5)

Note: () Standard errors.

As expected from examining the student level, some 14% of principals tested in South Africa reported that more than 90% of their students used language of test as their native language, and 78% of principals tested responded that that fewer than 50% of their students had language of test as the native language, as seen in Table 6.31 (below). In sharp contrast, most of principals (99%) in Korea reported more than 90% of their students had language of test as the native language.

Table 6.31 ***Students who have test language as 1st language***

		The percentage of student who have <language of test> as their native language			
		More than 90%	76-90%	50-75%	Less than 50%
% of schools	Korea	99(0.9)	-	-	-
	South Africa	14(2.7)	3(1.3)	5(1.7)	78(3.2)

Note: () Standard errors.

Some 99% (0.9) of the principals tested in Korea had been principals for less than 5 years. By contrast, South African principals tested had a wide range of experience as principal, ranging from 1 to 22 years. This can be explained by the different contexts that older and more experienced teachers can be a principal by passing some processes and it leads to short-term principals just before being retired in Korean schools. Unlike Korea, it seems that professional and trained staff can be a principal for longer periods in South African schools.

In both countries, schools expected parents to become more involved in school-related activities (Table 6.32). Of significance is that Korean schools expected parental involvement less as to 'raise funds for the school' and 'volunteer for school projects' than in other activities. It is very unusual to see raising funds for the school in Korea as the government supports schools financially. Most school projects in Korea are led by teachers or staff in schools other than parents or students.

Table 6.32 ***Schools' expectation for parents' involvement***

		Attend special events	Raise funds for the school	Volunteer for school projects, etc.	Ensure that children complete homework	Serve on school committee
% of schools	Korea	86(3.0)	36(4.1)	50(4.3)	83(3.2)	82(3.3)
	South Africa	95(1.6)	91(2.0)	91(2.0)	94(1.7)	100(0.0)

Note: () Standard errors.

With respect to science teachers in schools, both Korea (99%, 0.01) and South Africa (95%, 0.02) do not use incentives to retain or recruit science teachers. However, 52% (3.6) of principals tested in South Africa reported that it was somewhat or very difficult to fill Grade 8 teaching vacancies for science, as opposed to 13% (2.9) in Korea.

Table 6.33 ***The most frequent student behaviours occurring in Korean schools***

	Violating dress code			Classroom disturbance		
	Never or rarely	Monthly or weekly	Daily	Never or rarely	Monthly or weekly	Daily
% of schools	71(3.9)	15(3.1)	14(3.0)	69(4.0)	12(2.8)	19(3.4)

Note: () Standard errors.

In terms of students 'behavioural problems, the principals tested in Korea reported that 'violating dress code' (14%) and causing 'classroom disturbance' (19%) occurred daily the most often in schools (see Table 6.33). South African principals tested considered 'arriving late at school' (48%) and 'absenteeism' (27%) as the most frequent behaviours in schools daily (see Table 6.34).

Table 6.34 ***The most frequent behaviours occurring in South African schools***

	Arriving late at school			Absenteeism		
	Never or rarely	Monthly or weekly	Daily	Never or rarely	Monthly or weekly	Daily
% of schools	28(3.2)	24(3.0)	48(3.6)	31(3.3)	42(3.5)	27(3.2)

Note: () Standard errors.

With respect to severity of behaviour, Korean principals tested reported that 'physical injury to other students' (6%) and 'Intimidation or verbal abuse of other students' (4%) were the most serious behavioural problems in Korean schools, as seen in Table 6.35:

Table 6.35 ***The most serious student behaviours occurring in Korean schools***

	Intimidation or verbal abuse of other students		Physical injury to other students	
	Not or minor problem	Serious problem	Not or minor problem	Serious problem
% of schools	96(1.7)	4(1.7)	94(2.0)	6(2.0)

Note: () Standard errors.

Compared to Korean results, more than 30% of South African schools tested reported that 'arriving late at school' (39%) and 'absenteeism' (37%) were considered mostly as serious problems along with 'vandalism' (34%), as indicated in Table 6.36:

Table 6.36 ***The most serious student behaviours occurring in South African schools***

	Arriving late at school		Absenteeism		Vandalism	
	Not or minor problem	Serious problem	Not or minor problem	Serious problem	Not or minor problem	Serious problem
% of schools	61(3.5)	39(3.5)	63(3.4)	37(3.4)	66(3.4)	34(3.4)

Note: () Standard errors.

TIMSS made an index of availability of school resources for science instruction in order to measure the extent of school resources. Indexes were based on principals' average response to 11 questions, including five questions about general shortages and six science instruction-related shortages: instructional materials; budget for supplies; school buildings and grounds; heating/cooling and lighting systems; and instructional space; science laboratory equipment and materials; computers for science instruction; computer software for science instruction; calculators for science instruction; library materials relevant to science instruction; and audio-visual resources for science instruction. Schools having on average lower than 2 are assigned to high level. Where schools have on average greater than or equal to 3, they are assigned to low level. Schools with all other possible combinations of responses are assigned to medium level (Martin, Mullis, Gonzalez & Chrostowski, 2004). As described in Table 6.37, Korea indicated only 2% of students tested had low index value in sharp contrast to 39% of students tested in South Africa.

Table 6.37 ***Index of availability of school resources for science instruction (ASRSI)***

		High ASRSI	Medium ASRSI	Low ASRSI
% of students&	Korea	30(4.0)	67(3.9)	2(1.0)
	South Africa	9(2.0)	52(3.5)	39(3.5)

Source: Martin, Mullis, Gonzalez & Chrostowski, 2004.
Note: () Standard errors.
& % of students whose principal responded

Related to computer resources, South African principals tested indicated that the total number of computers in schools used for educational is on average nine with a standard deviation of 18 while Korean schools tested reported that there are on average 55 (SD, 33) computers in schools (see Table 6.38). Specifically, 55% (3.5) among schools tested in South Africa had no computers available for science instruction. This is in agreement with the result from the teacher level that over 86% (2.5) of South African teachers have no or little access to computers for use in science lessons, in sharp contrast to some 88% (2.0) of Korean teachers tested who have computers available for their science lessons.

Table 6.38 ***The number of computers in schools available for science instruction***

		Mean	SD
% of schools	Korea	55	33
	South Africa	9	18

In relation to the Internet access, as expected from computer availability, 60% of the cases of South Africa were missing, and among the responses the accessibility also shows low percentages as described in Table 6. 39:

Table 6.39 ***Computers access to the Internet for educational purposes***

		All	Most	Some	None
% of schools	Korea	83(3.2)	16(3.2)	1(0.9)	-
	South Africa	22(4.7)	2(1.6)	9(3.2)	67(5.3)

Note: () Standard errors.

6.4 CONCLUSION

This chapter explored TIMSS data by looking at the proportions of responses collected on various levels of Korea and South Africa. The exploration focused on description other than explanation of the differences between Korean and South African results. A descriptive exploration helps one take a snapshot of the science education of the two countries and items influencing student achievement in a broad sense. Exploration started with comparing the science achievements in TIMSS 2003. There was a wide gap between the two countries. As exploration on contextual backgrounds progressed across levels, the differences become distinguishable.

Korea and South Africa showed differences in many aspects at each level. Specifically, there are large differences in student language at home, parental educational level, students’ expectation to higher education, attitudes towards science, out-of-school activities, and ethnicity at the student level. The differences of interest at the teacher level include teacher background characteristics, limitations on instruction, topic coverage, homework, and assessment. Principals tested in both Korea and South Africa show such differences as stability/mobility of students, student background, community size, and resources. The explanation on the differences is detailed in the next chapter.

CHAPTER 7

RESULTS OF FACTOR, RELIABILITY, AND CORRELATION ANALYSES

7.1 INTRODUCTION

In this chapter, the results of factor, reliability and correlation analyses were explored, accounting for the case in Korea and in South Africa. The results presented here preceded the next analyses, namely multilevel analyses. Researchers argue that items should be clustered keeping valid homogeneity both empirically and conceptually (Bos, 2002). '*Empirically*' indicates that variables should have relevant loadings on one factor in factor analyses with a correlation coefficient of above 0.1 on the dependent variable, while '*conceptually*' implies variables should make sense based on literature. Empirical homogeneity can be underpinned by factor, reliability, and correlation analyses. Accordingly, the results of factor, reliability, and correlation analyses were used to select variables for inclusion in the multilevel analysis. Conceptual homogeneity can be supported by consulting the research framework that was based on comprehensive literature (Bos, 2002).

During the analyses of the TIMSS questionnaires, the conceptual framework developed in Chapter 4 was used as a guide for the identification of possible indicators of potential factors to be included in the multilevel analyses. In order to construct scales of validity, first, sets of items were examined in terms of factor analyses, and internal consistency of items that make up one scale was examined in light of reliability analyses. Sets of items or single-item scales confirmed were examined in terms of correlation analyses, which include relationships between a scale and science achievement, and between scales.

In particular, the interrelationships across the identified indicators were explored within each country to ensure that the assumptions of regression analyses were not violated. Overall, selection of variables for further analyses was made.

The structure of the chapter is as follows. First, factor analyses were conducted in Section 7.2, followed by reliability analyses in Section 7.3, and correlation analyses in Section 7.4. Lastly, based on the analyses conducted in advance, several potential factors to be included in the multilevel analyses were selected at various levels and presented in Section 7.5.

7.2 FACTOR ANALYSES

Several statistical analyses, including those of factor, reliability and correlation, were conducted in order to address the first research question, viz., *to what extent does TIMSS 2003 reflect factors related to effective science education?* The student, teacher, and school questionnaires consist of a large number of variables concerning background information, which are more than 600 separate background variables altogether. Some are single items and others consist of sets of items. Based on the conceptual framework described in Chapter 4, items of the questionnaires were reorganized and renamed. In particular, as regards sets of items, factor analysis was conducted to specify the underlying constructs in the two countries.

Firstly, missing data was dealt with, particularly considering that the two countries have a large enough sample size after removing all the missing cases. Where a missing case existed at the school, a teacher case and student cases collected in the same school were deleted along with the school case. In Korea, missing cases appeared only at the teacher level (101 cases). It was common that more than one teacher in each sampled school responded to the questionnaires in Korea. In the case of more than one teacher, aggregation was used to obtain an average for the variable.

When one teacher in one school participated in the study yet failed to complete the questionnaires (12 cases), the students taught by the teacher, the school and the teacher were all excluded. As a result, 137 cases at the school level, 256 cases at the class level, and 4,876 cases remained (Table 7.1):

Table 7.1 ***The process of excluding missing cases in Korean data***

Korea	School level	Teacher level	Student level
All cases	149	357	5,309
Missing case	0	101	0
Cases deleted due to missing teacher cases	12		433
Cases remaining	149-12=137	357-101=256	5,309-433=4,876

For South Africa, the process was complex since missing cases appeared in each level (Table 7.2, below). In contrast to Korea, one teacher in one school responded to the questionnaire. Therefore, if a missing case exists at any level, other-level cases collected at the same school should also be deleted. For example, schools named ID 27 and ID 133 were deleted due to there being too many missing values at the teacher samples, as were, accordingly, the student cases of the same schools. Likewise, student data (101 cases) in the schools named ID 28, ID 67 and ID 253 are missing. Consequently, the school data and teacher data in the schools ID 28, ID 67 and ID 253 were excluded. In summary, 198 cases among 255 schools, 198 cases among 255 teachers participating in TIMSS 2003, and 6,784 cases out of 8,952 students tested remained for further analysis:

Table 7.2 ***The process of excluding missing cases in South African data***

South Africa	School level	Teacher level	Student level
All cases	255	255	8952
Missing case	30	33	152=101+41
Missing in both school and teacher cases	9	9	
Missing student cases overlapped with school or teacher level			16
School or teacher case deleted due to missing student	3	3	
Cases deleted due to missing school or teacher cases			2032
Cases remaining	255-30-33+9-3 =198	255-30-33+9-3 =198	8952-152-2032+16 =6784

Once missing cases were dealt with the frequencies were examined to identify the missing data. For Korean student and school items of interest, below 5% of the data were missing, with a few of exceptions at the school level, while for teacher items, the percentage of missing data was under 15%. Meanwhile, South Africa had no more than 10% missing data for student, teacher and school items, with a few exceptions.

Missing data in the remaining cases was replaced by mean or median, given that the sample sizes in question were large in contrast to the amount of missing data at each level, which is not so important. Although this is regarded as a very traditional approach, it would be acceptable upon considering other sources of secondary research conducted previously (Bos, 2002; Howie, 2002). As mentioned in Chapter 5, depending on the format of items and the skew for items with more than 5% missing data, the missing data was replaced by using the mode, mean or median. However, this simple imputation can only be applied for the case in which missing data is not large as the results can be misleading and not be generalized (Howie, 2002). Therefore, where more than

20% of the data was missed, the items were excluded even though considered as important factors in light of the findings documented in earlier research. This was the case with parents' education level in South Africa, which had 33% and 39% missing data for father and mother education level respectively, similarly with educational expectation of students due to the high percentage of missing data (25%). Items related to computers also had a large amount of missing data and were deleted in the analysis.

Principal components analysis was applied to extract the factors, which were rotated using varimax rotation in which the axes are rotated and remain at right angles with each other, meaning that the factors do not correlate with each other. The Kaiser-Meyer-Olkin (KMO) was examined to measure the sampling adequacy for each question analysed and a value close to one indicates that the patterns of correlations are succinct, and thus the factor analysis should yield distinct factors, which are reliable. Besides KMO, the communalities were examined and if it was found that certain items did have low communalities (below 0.3) then the items were deleted since they would not load on the factors extracted. The researcher also evaluated components' loading value above 0.3 as a criterion, since the size of the loading is important and the highest loading is normally taken, with this criterion applied for the whole analyses. Furthermore, double-loading items, which mean one item loads on more than one factor, were eliminated to make the rotated factor pattern form a simple structure (Blaikie, 2003; Schönrock-Adema et al., 2009). The details of the results obtained are described in Appendix E and F. Analyses of the items intended to make up one scale revealed a meaningful distinction in item content, which resulted in two or three separate subscales.

7.2.1 STUDENT LEVEL

The student questionnaire consists of 23 questions, four of which were excluded as the questions were mathematics-related. There were various subsections in the questions and at times the stem was used with a number of sub-items. Even though questions consist of multiple items the format is dichotomous, such as “yes/no”, and only examined by means of reliability and correlation analysis (‘home possession’ and ‘safety in school’). Six questions, which consist of multiple items and Likert scale, were scrutinized by means of factor analyses at the student level. The results for Korea and South Africa are presented as follows.

7.2.1.1 Korean student-level factors extracted

Six sets of items at the student level were examined in terms of factor analyses. Out of those sets, questions on ‘liking science’, ‘valuing science’, ‘school climate’, and ‘computers’ are extracted into one component respectively, as described in Table 7.3 (hereafter ‘factor’ replaces the term ‘component’). As expected, each item shows high loading value on each factor.

Table 7.3 ***Liking science, valuing science, computers, and school climate in Korea***

Items	Component	Factor renamed
	1	
do well in science	**.819**	Liking science
take more science	**.686**	
enjoy learning science	**.766**	
learn science quickly	**.776**	
science is more difficult	**.745**	
not understand a new topic	**.597**	
science is not a strength	**.789**	
for daily life	**.684**	Valuing science
for other subjects	**.723**	
for university	**.811**	
for science job	**.740**	
for job I want	**.819**	
look up ideas for science	**.694**	Computer use
write reports	**.832**	
analyze data	**.865**	
like being in school	**.691**	Liking school
student do the best	**.731**	
teacher care about student	**.794**	
teacher want student to do best	**.694**	

The results of ‘learning activities in science’ revealed that 12 items loaded on three distinct factors, viz., ‘lecture learning’, ‘practical learning’, and ‘STS learning’ (Table 7.4, below). Lecture learning can be referred to as ‘teacher-centred teaching practice’, and is common in Korean science classes. Practical learning was extracted first and named as such because practical work such as demonstration or experiment is the most common practice related to inquiry activities in Korea, unlike activities such as ‘formulating hypothesis’ or ‘designing experiment’, which might explain why those items were double-loaded. As a result, they were excluded, although their concepts are strongly related to ‘inquiry learning’. Out of 14 items, three were loaded on Society, Technology and Science (STS) learning, while the other were excluded owing to low communalities and double-loadings, with the loading being higher on another component (see Appendix E).

Table 7.4 ***Learning activities in science in Korea***

Items	Component			Factor renamed
	1	2	3	
watch demonstration student	**.576**	.178	-.011	Practical learning
conduct experiment student	**.792**	.199	.026	
work in small group student	**.783**	-.007	.255	
write explanation student	**.736**	.119	.288	
technology on society student	.175	**.679**	.006	STS learning
relate to daily life student	.088	**.687**	.185	
review homework student	.147	**.569**	.287	
listen to lecture student	.107	.247	**.766**	Lecture learning
formulate hypothesis student$^{@}$	.514	.468	-.149	
design experiment student$^{@}$	.657	.397	-.089	
work problem student$^{@}$	.110	.437	.587	
present work student$^{@}$	.401	.569	-.005	
have quiz*	.148	.458	.042	
begin homework$^{\#}$	.003	.371	-.479	

Note: $^{@}$ *deleted due to double-loading*
* *deleted due to low item total correlation in reliability analyses*
$^{\#}$ *deleted due to low communalities*

The nine items of ‘Out-of-school activities’ also loaded on three distinct factors which are ‘play after school’, ‘study after school’, and ‘work after school’ as seen in Table 7.5 (below). These three factors were relatively unrelated. ‘Play after school’ is the first factor extracted and Korean students are more likely to play on the computer or watch television than engage in other activities during their leisure time after school. ‘Study after school’ consisted of two items, namely ‘read book for enjoyment’ and ‘do homework’. Korean students tend to regard even reading a book for fun as an activity related to study. An item ‘do jobs at home’ was deleted due to being double loaded on both component 1 and 2 to make a factor pattern simple. ‘Work after school’ consists of two items, such as ‘work paid job’ and ‘play sports’ that are conceptually unrelated to each other. This could be the result of Korean students being less likely to spend their after-school time on those kinds of activities than others. For this reason the factor was excluded from further discussion.

Table 7.5 ***Out-of-school activities in Korea***

Items	**Component**			**Factor renamed**
	1	**2**	**3**	
watch TV or video	**.705**	.019	-.038	Play after school
play computer game	**.673**	-.259	.225	
use internet	**.753**	-.039	.071	
play with friend	**.555**	.187	-.005	
read book for enjoy	-.129	**.613**	.224	Study after school
do homework	-.028	**.759**	-.147	
work paid job	-.012	-.066	**.826**	Work after school
play sports	.144	.283	**.587**	
do jobs at home[@]	.362	.556	.242	

Note: [@] *deleted due to double-loading*

The student-level factors obtained from the Korean data were summarized in Table 7.6 (below). Ten factors were extracted in total from factor analyses and nine factors excluding ‘work after school’, as mentioned above, were examined at the next analysis, that of reliability.

Table 7.6 ***Student-level factors extracted in Korea***

Item Content	Number of items	Component extracted	KMO & Bartlett's test	Factor Loading range	Factor renamed
Liking science	7	1	0.868	0.597-0.819	Liking science
Valuing science	5	1	0.757	0.684-0.819	Valuing science
Learning activities in science	14	3	0.854	0.576-0.792 0.569-0.687 0.766	Practical learning STS learning Lecture learning
Computers	3	1	0.629	0.651-0.978	Computer use
School climate	4	1	0.729	0.691	Liking school
Out-of-school activities	9	3	0.664	0.673-0.753 0.613-0.759 0.587-0.826	Play after school Study after school Work after school

7.2.1.2 South African student-level factors extracted

Out of six sets of items examined, as in Korea, ‘valuing science’ and ‘school climate’ are extracted into one factor respectively (Table 7.7, below). ‘Valuing science’ shows similar results in keeping with the Korean context, except that the ‘for science job’ item was deleted due to low communalities, below 0.3 (see Appendix F). This low value might imply that South African students tend not to relate science study to a future career.

Table 7.7 ***Valuing science and school climate in South Africa***

Items	Component 1	Factor renamed
for daily life	**.742**	Valuing science
for other subjects	**.741**	
for university	**.789**	
for science job[#]	**.519**	
for job I want	**.824**	
like being in school	**.746**	Liking school
student do the best	**.788**	
teacher care about student	**.823**	
teacher want student to do best	**.813**	

Note: [#] *deleted due to low communalities*

Importantly, the results of ‘liking science’ show that positively and negatively phrased items were loaded on different factors, as opposed to one factor extracted in Korea (see Table 7.8, below). This might indicate that South African students have difficulty in understanding what they are supposed to acquire from school learning. Scherman (2005) documented that negatively phrased questions might affect the student response pattern in South Africa due to language difficulty. She found that the negatively phrased items affected the reliability negatively in the process of developing a school climate instrument, and this could be explained by the learners being second language speakers in South Africa, and their having difficulty in switching between positively and negatively phrased questions.

Table 7.8 ***Liking science in South Africa***

Items	**Component**		**Factor renamed**
	1	**2**	
do well in science	**.741**	.067	Enjoying science
take more science	**.772**	.024	
enjoy learning science	**.580**	-.023	
learn science quickly	**.779**	.072	
science is more difficult	.022	**.770**	Self-confidence
not understand a new topic	.002	**.750**	
science is not a strength	.070	**.714**	

‘Learning activities in science’ for South Africa show quite a different picture compared to the Korean results as described in Tables 7.9 (below). The different results may indicate that learning science practice is perceived differently in the two countries. ‘STS learning’ in Korea can be a reflection of Korean science teacher tendency to teach science that is related to daily life, and a reluctance to give homework to their students. Meanwhile, homework-centred practice (see ‘lecture learning’ in Table 7.9, above) is mainly adopted by science teachers in South Africa, consistent with findings in Section 6.3. Furthermore, it is of help to contrast ‘inquiry learning’ in South Africa with ‘practical learning’ in Korea, and as implied in the factor names, science learning is more inquiry-directed in South Africa and more practice-directed in Korea.

Table 7.9 ***Learning activities in science in South Africa***

Items	Component			Factor renamed
	1	2	3	
watch demonstration student	**.623**	.068	.020	Inquiry learning
formulate hypothesis student	**.684**	.049	.130	
design experiment student	**.662**	.183	.077	
conduct experiment student	**.668**	.145	.116	
write explanation student	**.500**	.254	.007	
present work student	.158	**.629**	.124	Lecture learning
review homework student	.075	**.631**	.249	
listen to lecture student	.059	**.668**	-.054	
work problem student	.142	.087	**.701**	Student learning
begin homework	.040	.108	**.790**	
work in small group student@	.443	.350	.019	
technology on society student@	.385	.362	.155	
relate to daily life student@	.355	.481	-.076	
have quiz#	.281	.420	.163	

Note: @ *deleted due to double-loading*
\# *deleted due to low communalities*

Another question giving a different result is 'out-of-school activities' as seen in Table 7.10 (below). Different results indicate that students in the two countries spend their leisure time differently. The differences can be explained in terms of the culture of the two countries. For example, in contrast to the prevailing computer and Internet usage in Korea, the distribution of IT is still limited though ongoing in South Africa. Korean students spend the majority of their leisure time on activities related to computer and the Internet. In contrast, South African students are the most likely to spend their time on homework, employment, or reading books at home, considering that they are loaded on the first factor. Some items that are not related to each other in terms of the conceptual framework were loaded on the same factor. That was the case with 'work paid jobs' and 'use Internet'. As those activities are not related to each other conceptually, although high loading values, the items were no longer discussed as in the Korean data. 'Watch TV or video' constitutes a single-item factor as named 'media', and was discussed further in the section of correlation analysis.

Table 7.10 ***Out-of-school activities in South Africa***

Items	Component			Factor renamed
	1	2	3	
do jobs at home	**.718**	-.045	-.030	Study after school
read book for enjoy	**.671**	.123	-.034	
do homework	**.741**	-.060	.066	
work paid job	.145	**.683**	-.210	Work after school
use internet	.058	**.753**	.007	
watch TV or video	.179	-.039	**.869**	Mass media
play computer game@	-.218	.647	.422	
play with friend@	.594	-.089	.354	
play sports@	.530	.221	.148	

Note: @ deleted due to double-loading

Six questions which consist of multiple items and Likert scale were scrutinized by means of factor analyses at the student level. There are obvious differences identified at the student level between Korea and South Africa and learning activities' and 'out-of-school activities' are distinct from other factors.

Table 7.11 ***Student-level factors extracted in South African data***

Item Content	Number of items	Component extracted	KMO & Bartlett's test	Factor Loading range	Factor renamed
Liking science	7	2	0.701	0.580-0.779 0.714-0.770	Enjoying science Self-confidence
Valuing science	5	1	0.812	0.741-0.824	Valuing science
Learning activities in science	14	3	0.894	0.500-0.684 0.629-0.668 0.701-0.790	Inquiry learning Lecture learning Student learning
School climate	4	1	0.794	0.746-0.823	Liking school
Out-of-school activities	9	3	0.728	0.671-0.741 0.683-0.753 0.869	Study after school Work after school Mass media

7.2.2 CLASSROOM LEVEL

The teacher questionnaire consisted of 34 questions, eight of them made up of multiple items, and selected from a point of factor analysis. Even though questions consist of multiple items, if the format is dichotomous, such as "yes/no", or the question consists of items unrelated to each other from a perspective of the research framework, it is inappropriate for factor analysis. Such questions were also excluded. As expected from a number of questions compared to other questionnaires, the results of factor analysis for the teacher questionnaire show quite a complex picture, in contrast to those at the student level in both Korea and South Africa.

7.2.2.1 Korean classroom-level factors extracted

The 'preparation to teach' question consists of five contents, viz., physics, chemistry, biology, earth science, and environment, the results of factor analysis on which confirmed these five areas (see Appendix E). 'Preparation to teach' is important in terms of teacher qualification, as well as teaching practice. Research also shows it is related to student achievement as reviewed in Chapter 3. Despite the importance, successive analyses did not show any points of interest in terms of student achievement. 'Teacher interaction' resulted in two factors extracted as in Table 7.12 (below), but low KMO (0.526) (see Appendix E). Therefore, it should be excluded in further analyses as criterion value of KMO is at least 0.6. However, considering that Field (2005) states anything lower 0.5 is unacceptable, despite the low KMO, two factors extracted are worth discussing further because they consist of items that have to do with the values or esteem that develops through colleague interaction or material information. For that reason, two factors extracted here were examined in the discussion of correlation analysis.

Table 7.12 ***Teacher interaction in Korea***

Items	Component		Factor renamed
	1	2	
interact pedagogy	**.855**	.191	Inform-interaction
interact materials	**.887**	-.052	
interact by visiting	-.024	**.870**	Visit-interaction
interact by observing	.153	**.846**	

The ‘attitudes toward science subject’ question turned out to have three factors extracted, namely ‘inquiry practice’, ‘knowledge practice’, and ‘abstract practice’ (Table 7.13, below). The first factor extracted was ‘inquiry practice’. A possible explanation might be that Korean science teachers are more likely than teachers in other countries to regard the subject science as inquiry practice.

Table 7.13 ***Attitudes toward subject in Korea***

Items	Component			Factor renamed
	1	2	3	
more than 1 representation	**.654**	.045	.425	Inquiry practice
solving by hypothesis	**.775**	.033	-.052	
scientific theories	**.541**	-.172	-.057	
scientific investigation	**.673**	.121	-.212	
getting correct answer	-.090	**.677**	-.128	Knowledge practice
skill and knowledge	-.180	**.712**	.304	
modelling phenomena	.240	**.660**	.025	
learning by memorizing	.052	.254	**.714**	Abstract practice
scientific discoveries	-.183	-.156	**.644**	

The ‘school setting’ question resulted in one factor (Table 7.14, below) and was defined as ‘school environment’. ‘School setting’ is a parallel question to ‘safety in school’ at the student level, which is discussed in reliability analyses and thus comparatively analyzed at a stage of selection of variable in Section 7.5.

Table 7.14 ***School setting in Korea***

Items	Component	Factor renamed
	1	
school facility repair	**.620**	School environment
safe neighbourhood	**.725**	
feel safe at school	**.810**	
security policy of school	**.616**	

‘School climate’ has two factors extracted as seen in Table 7.15 (below). Five of the ‘school climate’ items were loaded on one factor and called ‘high expectation’ by teacher, parent, and student. The second factor extracted included items that have to do with ‘professional teaching force’ expected from science teachers.

Table 7.15 ***School climate in Korea***

Items	Component		Factor renamed
	1	2	
teacher expectation for student	**.635**	.374	High expectation
parent support for student	**.856**	.133	
parent involvement in school	**.840**	.140	
student regard for school	**.712**	.213	
student desire to do well	**.815**	.038	
teacher job satisfaction	.207	**.702**	Professional teaching force
teacher understand curriculum	.194	**.819**	
teacher success in curriculum	.047	**.830**	

‘Content-related activities’ show three factors extracted as described in Table 7.16 (below). The first factor extracted is called ‘STS work’ because all items that were loaded on this factor have to do with activities related to STS. This factor seems to indicate that Korean science teachers are the most likely to relate scientific knowledge to daily life or technology in order to help students better understand what they teach. The second factor extracted included items involved in practical work and was termed accordingly. The last factor extracted is ‘inquiry work’, which may be an activity that happens less often than other activities in Korean science classrooms. Many items such as ‘design experiment’, ‘conduct experiment’, ‘put event in order’, or ‘present work’ were excluded, due to their being double-loaded and in order to make a factor pattern clear.

Table 7.16 ***Content-related activities in Korea***

Items	Component			Factor renamed
	1	2	3	
technology on society	**.727**	.090	-.056	STS work
learn nature and inquiry	**.817**	.167	.239	
relate to daily life	**.661**	.038	.135	
work in small group	-.082	**.758**	.419	Practical work
write explanation	.313	**.686**	.081	
watch demonstration	-.004	.209	**.674**	Inquiry work
formulate hypotheses	.382	-.142	**.745**	
design experiment@	.228	.409	.618	
conduct experiment@	-.046	.611	.589	
put event in order@	.579	.416	.205	
present work@	.436	.596	-.053	

Note: @ deleted due to double-loading

The items of ‘factors limiting teaching’ were loaded on three factors, with one item, ‘limit in textbook’, deleted due to low communalities, and another item, ‘limit in stu/tch ratio’ due to low loading value, as shown in Table 7.17 (below). A possible explanation may be that textbooks are given free of charge to students in Korea when the academic schedule starts every year. Therefore, textbooks are considered as easily accessible material in Korean schools. The first factor extracted included items related to students who are mainly disadvantaged, for example, whether they come from low SES, have low morale or are uninterested in education. Therefore, this factor is called ‘student resource’. The second factor extracted contained items mainly related to material such as physical facilities and equipment, and was thus defined as ‘physical resource’. The last factor extracted is named ‘computer resource’, because all items included in the factor have to do with computers.

Table 7.17 ***Factors limiting teaching in Korea***

Items	**Component**			**Factor renamed**
	1	**2**	**3**	
limit in academic difference	**.662**	.049	.224	Student resource
limit in background	**.557**	.164	.089	
limit in special need	**.550**	.189	-.150	
limit in uninterest	**.881**	.006	.121	
limit in low morale	**.855**	.046	.086	
limit disruptive student	**.799**	.093	.131	
limit in other equipment	.206	**.815**	.188	Physical resource
limit in equipment	.221	**.773**	.260	
limit in physical facility	.224	**.611**	.283	
limit in hardware	-.002	.054	**.877**	Computer resource
limit in software	.169	.217	**.749**	
limit in using computer	.128	.246	**.780**	
limit in textbook#	-.104	.667	-.020	
limit in stu/tch ratio&	.347	.299	.299	

Note: # *deleted due to low communalities*
& *deleted due to low loading value*

‘Topic coverage’ is important in terms of the research framework because this represents an opportunity to learn and has been found as being strongly related to student achievement. The first run of factor analysis revealed too many factors (10) to be extracted. Therefore, the items were forced to load on five factors to be extracted with the five factors emerging from five content areas, viz., physics, earth science, chemistry, biology, and environment. The result however, did not show a consistent and meaningful picture, unlike the expectation, and thus the items were excluded. The detailed information can be found in Appendix E.

From the descriptive statistics explored in Chapter 6, it is expected that homework factors do not have strong effects on student achievement in Korea, because teachers in this country do not use homework as much as other counterparts in TIMSS. TIMSS has two questions related to homework, which are ‘type of homework’ and ‘use of homework’. The former has three factors extracted (Table 7.18, below), with two items, ‘homework on application’ and ‘homework on definition’, deleted due to double-loading. Items related to simple knowledge were loaded on a factor. For this reason, the factor is defined as ‘knowledge homework’. The other factor included items involved in inquiry activities, such as application or investigation, was defined as ‘inquiry homework’. The third factor is a single factor and is defined as ‘project homework’. It is assumed from the results that Korean science teachers tested are more likely to give students basic homework such as solving problems or using textbooks than other complex tasks, such as carrying out investigation or doing projects.

Table 7.18 ***Type of homework in Korea***

Items	**Component**			**Factor renamed**
	1	**2**	**3**	
homework on problem	**.781**	-.139	.025	Knowledge homework
homework on textbook	**.729**	.091	.184	
homework on investigation	-.182	**.824**	.012	Inquiry homework
homework on report	.076	**.591**	.222	
homework on project	.196	.219	**.834**	Project homework
homework on application[@]	.528	.298	-.501	
homework on definition[@]	.468	.595	-.182	

Note: [@] *deleted due to double-loading*

‘Use of homework’ is not considered appropriate for factor analysis because the question consists of items that are inconsistent. The results also show a remarkably different picture in the two countries (see Appendices E and F). In addition, many items were double-loaded and reliability analysis resulted in many items with low Corrected Item-Total Correlation values (see Appendix G). Therefore, it was excluded from the factor analysis.

Table 7.19 ***Classroom-level factors extracted in Korean data***

Item Content	Number of items	Component extracted	KMO & Bartlett’s test	Factor Loading range	Factor renamed
Preparation to teach	21	5	0.894	0.782-0.861	Pchemistry
				0.706-0.830	Pphysics
				0.629-0.847	Pbiology
				0.810-0.858	Penvironment
				0.529-0.861	Pearth science
Teacher interaction	4	2	0.526	0.855-0.887	Inform-interaction
				0.846-0.870	Visit-interaction
Attitudes toward science subject	9	3	0.625	0.541-0.775	Inquiry practice
				0.660-0.712	Knowledge practice
				0.644-0.714	Abstract practice
School setting	5	1	0.676	0.616-0.810	School environment
School climate	8	2	0.774	0.635-0.856	High expectation
				0.702-0.830	Professional teaching force
Content-related activities	11	3	0.769	0.661-0.817	STS work
				0.686-0.758	Practical work
				0.674-0.745	Inquiry work
Factors limiting teaching	14	3	0.811	0.557-0.881	Student resource
				0.611-0.815	Physical resource
				0.749-0.877	Computer resource
Type of homework	7	3	0.597	0.528-0.781	Inquiry homework
				0.591-0.824	Knowledge homework
				0.834	Project homework

The results obtained at the classroom level were summarized in Table 7.19 (above). There were 22 factors extracted, most of which were examined in the next analyses to see if they had internal consistency.

7.2.2.2 South African classroom-level factors extracted

In contrast to the Korean results concerning ‘preparation to teach’, ‘physics and chemistry’, and ‘earth science’ and ‘environment’ were loaded on the same factor respectively (see Appendix F). In particular, the physics-chemistry factor reflects on the current South African curriculum, where the two areas are integrated into one subject. ‘Teacher interaction’ shows low KMO (0.516), as in the Korean data, and each item was double-loaded, unlike Korea (see Appendix F). Nonetheless these two factors, viz., ‘inform-interaction’ and ‘visit-interaction’, will be discussed in the next analysis, due to the high correlation with achievement and because they make conceptual sense.

The ‘attitudes toward science subject’ question resulted in three factors, which are ‘inquiry practice’, ‘knowledge practice’, and ‘abstract practice’ (Table 7.20, below). As expected, attitudes toward the subject science show a slightly different picture from those in the Korean results. Consequently, it might be assumed that Korean and South African teachers have a slightly different perception of science education. For example, the latter are more likely to consider that acquiring skill and knowledge is part of the inquiry process, whereas the Korean teachers regard it as a knowledge process.

Table 7.20 ***Attitudes toward subject in South Africa***

Items	Component			Factor renamed
	1	2	3	
more than 1 representation	**.746**	.041	.179	Inquiry practice
solving by hypothesis	**.756**	-.044	.157	
scientific investigation	**.750**	-.160	-.068	
skill and knowledge*	**.651**	.278	-.033	
modelling phenomena	**.745**	.172	-.072	
scientific discoveries	.008	**.820**	-.097	Abstract practice
getting correct answer	.023	.025	**.894**	Knowledge practice
scientific theories[@]	.538	.383	-.228	
learning by memorizing[@]	.092	.662	.413	

*Note: * deleted after reliability analysis due to low Corrected Item-Total Correlation*
[@] deleted due to double-loading

‘School setting’ items were loaded on one factor, which is a similar result to the Korean one except that the ‘school facility repair’ item was deleted due to low communalities (0.256), despite high loading value (Table 7.21, below. See Appendix F).

Table 7.21 ***School setting in South Africa***

Items	Component	Factor renamed
	1	
safe neighbourhood	**.862**	School environment
feel safe at school	**.898**	
security policy of school	**.844**	
school facility repair#	**.506**	

Note: # deleted due to low communalities

Four of the ‘school climate’ items were loaded on two factors, as in Korea. However, items that constitute each factor are a little different, as seen in Table 7.22 (below). Items regarding parents and students were loaded on one factor, called ‘high expectation’, and items that have to do with teachers were loaded on the other factor, called ‘professional teaching force’. It is of interest that South African teachers tested distinguished teachers from parents and students. In contrast, ‘high expectation’ includes items related to by teachers as well as parents and students in Korea.

Table 7.22 ***School climate in South Africa***

Items	Component		Factor renamed
	1	2	
parent support for student	**.726**	.349	High expectation
parent involvement in school	**.844**	.173	
student regard for school	**.841**	.153	
student desire to do well	**.770**	.157	
teacher job satisfaction	.338	**.570**	Professional teaching force
teacher success in curriculum	.190	**.854**	
teacher understanding curriculum	.186	**.802**	
teacher expectation for student	.100	**.713**	

‘Content-related activities’ shows three factors extracted (Table 7.23., below) The first factor extracted is called ‘STS work’, the second factor ‘practical work’, and the last defined as ‘inquiry work’, due to reasons similar to those mentioned in the Korean data. There seem to be more similarities in ‘content-related activities’ between Korea and South Africa than other factors extracted.

Table 7.23 ***Content-related activities in South African data***

Items	Component			Factor renamed
	1	2	3	
technology on society	**.744**	.151	.108	STS work
learn nature and inquiry	**.795**	-.014	.057	
present work	**.507**	.251	.162	
relate to daily life	**.659**	.063	.198	
work in small group	.085	**.780**	.163	Practical work
write explanation	.202	**.841**	.053	
watch demonstration	.178	-.176	**.748**	Inquiry work
formulate hypotheses	.182	.113	**.591**	
design experiment	.100	.376	**.644**	
conduct experiment$^{@}$	.055	.465	.647	
put event in order$^{@}$	.506	.462	.124	

Note: $^{@}$ *deleted due to double-loading*

The items of ‘factors limiting teaching’ were loaded on four factors (Table 7.24, below). The first factor extracted included items related to material such as physical facilities, textbooks, and equipment, and thus was defined as ‘physical resource’. Compared to the first factor of Korea, ‘student resource’, South African teachers tend to regard ‘physical resource’ as the greatest challenge. The second factor extracted contained items mainly related to computers and named ‘computer resource’. Both the third and the last factor extracted have to do with students and, more specifically, ‘student morale’ and ‘student SES’. It is worth noting that these two factors were integrated in the Korean data as ‘student resource’. ‘Limit in special need’ item was deleted due to being double-loaded (Table 7.24).

Table 7.24 ***Factors limiting teaching in South Africa***

Items	Component				Factor renamed
	1	2	3	4	
limit in other equipment	**.812**	.371	-.046	.168	Physical resource
limit in equipment	**.876**	.233	.016	.042	
limit in physical facility	**.790**	.344	.059	.083	
limit in stu/tch ratio	**.495**	-.084	.235	.201	
limit in textbook	**.666**	.175	.109	.059	
limit in hardware	.225	**.921**	.090	.088	Computer resource
limit in software	.246	**.921**	.091	.119	
limit in using computer	.297	**.860**	.078	.094	
limit in uninterest	.076	.039	**.838**	.121	Student morale
limit in low morale	.044	.166	**.814**	.205	
limit disruptive student	.078	.043	**.821**	-.002	
limit in academic difference	.129	.185	.167	**.817**	Student SES
limit in background	.154	.070	.152	**.850**	
limit in special need[@]	.103	.012	.453	.364	

Note: [@] *deleted due to double-loading*

With respect to ‘opportunity to learn’ (OTL), ‘topic coverage’ resulted in 12 factors extracted, two more than in the Korean data. Therefore, the items were forced to have only five factors extracted, as in the Korean case (see Appendix F). Although OTL proved an important factor in terms of student achievement, as reviewed in Chapter 3, results of analyses on the OTL items did not show any point of interest and thus is not discussed in the next analyses.

‘Type of homework’ has two factors extracted (Table 7.25, below). Compared to Korean results on the same items, there are some differences to note between Korea and South Africa. As pointed out above, Korean teachers prefer to give simple knowledge-related homework. In contrast, South African teachers tested seem to give more complicated homework, such as making investigation or embarking on projects.

Table 7.25 ***Type of homework in South Africa***

Items	Component		Factor renamed
	1	2	
homework on problem	**.416**	.157	Inquiry homework
homework on project	**.646**	-.072	
homework on investigation	**.785**	-.101	
homework on report	**.638**	.191	
homework on textbook	.036	**.806**	Knowledge homework
homework on definition	.087	**.793**	
homework on application[@]	.519	.348	

Note: [@] *deleted due to double-loading*

Regarding 'use of homework', as opposed to inconsistent results in Korea, South African results show a clear picture (Table 7.26, below). Items were loaded on two factors distinctly, however it is noted that the result of factor analysis also shows low communalities (0.548), meaning it is inappropriate for factor analysis (see Appendix F). Nonetheless, homework is more likely to be given in South African than in Korean schools, and a significant relationship with student achievement shown in correlation analyses is discussed in further analyses, related to opportunity to learn or time on task from a perspective of the conceptual framework.

Table 7.26 ***Use of homework in South African data***

Items	Component		Factor renamed
	1	2	
homework correct	**.715**	.066	Extensive homework
homework discussion	**.771**	.051	
homework grade	**.597**	.043	
homework monitor	.162	**.823**	Basic homework
homework feedback	-.027	**.859**	

All factors extracted in the South African data are summarized in Table 7.27 (below). There are 22 factors identified at the classroom level, some of which have been examined in reliability analyses to make up scales of validity.

Table 7.27 ***Classroom-level factors extracted in South Africa***

Item Content	Number of items	Component extracted	KMO & Bartlett's test	Factor Loading range	Factor renamed
Preparation to teach	21	3	0.883	0.684-0.842 0.632-0.923 0.747-0.856	Pphysics & Chemistry Pbiology Pearth science & Environment
Teacher interaction	4	2	0.516	0.886-0.891 0.839-0.845	Inform-interaction Visit-interaction
Attitudes toward science subject	9	3	0.797	0.651-0.756 0.894 0.820	Inquiry practice Knowledge practice Abstract practice
School setting	5	1	0.745	0.844-0.898	School environment
School climate	8	2	0.806	0.726-0.844 0.570-0.854	High expectation Professional teaching force
Content-related activities	11	3	0.781	0.506-0.795 0.780-0.841 0.591-0.748	STS work Practical work Inquiry work
Factors limiting teaching	14	4	0.804	0.495-0.876 0.860-0.921 0.814-0.838 0.817-0.850	Physical resource Computer resource Student morale Student SES
Type of homework	7	2	0.644	0.638-0.785 0.793-0.806	Inquiry homework Knowledge homework
Use of homework	5	2	0.548	0.597-0.771 0.823-0.859	Extensive homework Basic homework

7.2.3 SCHOOL LEVEL

The school questionnaire consisted of 25 questions, four of which were made up of multiple items and were thus investigated by means of factor analysis. As in the student and teacher questionnaires, even though questions consisted of multiple items, using a Likert scale format, if they did not make conceptual sense they were only examined by means of a reliability or correlation analysis (e.g., teacher evaluation). The overall information of school questionnaire is found in Appendix D.

7.2.3.1 Korean school-level factors extracted

The first question examined for factor analysis in the school questionnaire relates to ‘school climate’ and it is a parallel question that also appears in the teacher questionnaire. However, all the items here were loaded on a single factor, in contrast to the two factors extracted at the teacher level (Table 7.27, below). It was defined as ‘educational ethos’. The ‘professional development’ question has five items and four of them were loaded on one factor, excluding ‘develop school goal’ due to low communalities (0.257) as described in Table 7.28 (see Appendix E).

Table 7.28 ***School climate and professional development in Korea***

Items	**Component**	**Factor renamed**
	1	
teacher job satisfaction-p	**.695**	Educational ethos
teacher understand goals	**.773**	
teacher degree of success	**.808**	
teacher expect student	**.811**	
parent support student	**.768**	
parent involve school	**.758**	
student regard school	**.706**	
student desire do well	**.805**	
develop curriculum	**.700**	Professional development
develop content knowledge	**.812**	
develop teaching skill	**.759**	
develop ICT	**.634**	
develop school goal#	**.507**	

Note: # deleted due to low communalities

The ‘student behaviour’ question was examined via two aspects, which are ‘frequencies’ and ‘severity’. Items related to frequency of behaviour, loaded on three factors, and were defined as ‘low moralef’, ‘bullyingf’, and ‘disrespectf’ respectively as shown in Table 7.29. The “f” is added at the end of factors renamed in Table 7.29 to indicate frequency of behaviour. A single item, ‘frequency of cheating’, was excluded in further analysis due to being double-loaded.

Table 7.29 ***Student behaviour (frequencies) in Korea***

Items	Component			Factor renamed
	1	2	3	
frequency of late arrival	**.849**	.162	-.122	Low moralef
frequency of absenteeism	**.667**	.272	-.181	
frequency of skipping	**.661**	.141	.280	
frequency of dress code	**.764**	.221	.041	
frequency of disturbance	**.695**	.310	.050	
frequency of profanity	.184	**.757**	.041	Bullyingf
frequency of vandalism	.223	**.726**	-.042	
frequency of theft	.250	**.665**	.208	
frequency of intimidating student	.183	**.799**	.053	
frequency of injury to student	.308	**.588**	.362	
frequency of intimidating teacher	.054	.177	**.753**	Disrespectf
frequency of injury to teacher	-.120	-.043	**.691**	
frequency of cheating@	.420	.274	.410	

Note: @ deleted due to double-loading

Related to severity of student behaviour, just as in the frequency of student behaviour, an “s” added at the end of the factor renamed stands for the “severity” of student behaviour as described in Table 7.30 (below). Items of severity were loaded on two factors, but many items were double-loaded on these two factors as described in Table 7.30. It should be noted that the double-loaded items excluded are mainly the ones related to bullying behaviour. A possible explanation for this could be that behaviour, such as cheating, profanity, vandalism, or theft, may not be as serious as low morale in Korean schools, and subsequently the principals tested might not respond as accurately as possible. Therefore, all double-loaded items were deleted in further analysis and items related to low morale remained.

Table 7.30 ***Student behaviour (severity) in Korea***

Items	Component		Factor renamed
	1	2	
severity of late arrival	**.760**	.229	Low morales
severity of absenteeism	**.667**	.162	
severity of skipping	**.767**	.106	
severity of dress code	**.762**	-.012	
severity of disturbance	**.807**	.144	
severity of intimidating teacher	.180	**.886**	Disrespects
severity of injury to teacher	.004	**.889**	
severity of cheating$^{@}$	.493	.621	
severity of profanity$^{@}$	.695	.386	
severity of vandalism$^{@}$	.710	.364	
severity of theft$^{@}$	.633	.501	
severity of intimidating student$^{@}$	.719	.428	
severity of injury to student$^{@}$	.633	.536	

Note: $^{@}$ *deleted due to double-loading*

The last question examined for factor analysis, ‘instructional resources’, has four factors extracted (Table 7.31). The question also has some double-loaded items but this time none of them are excluded, and some items are included due to relatively low double-loading values (Table 7.31) and their being conceptually obvious. Generally speaking, resources are not seen as a challenge in Korean schools and it may be assumed that the principals tested responded to the question approximately on resource or facility.

Table 7.31 ***Instructional resources in Korea***

Items	Component				Factor renamed
	1	2	3	4	
shortage of lab equipment	**.758**	.130	.244	.034	Science resource
shortage of AV for science	**.785**	.299	.176	.194	
shortage of computer for science	**.787**	.380	.144	-.141	
shortage of software for science	**.783**	.442	.100	-.063	
shortage for handicapped	.107	**.558**	.189	-.062	Math resource
shortage of computer for math	.298	**.697**	.246	-.066	
shortage of software for math	.208	**.701**	.315	-.011	
shortage of calculator for math	.002	**.825**	.044	.275	
shortage of calculator for science	.230	**.658**	.002	.254	
shortage of library for math	.336	**.668**	.054	.294	
shortage of building and ground	.053	.163	**.746**	.305	Infra resource
shortage of heat/cool and light	.222	.133	**.754**	.128	
shortage of space	.155	.193	**.768**	.121	
shortage of material	.191	.111	.229	**.776**	Budget
shortage of budget	.016	.207	.292	**.766**	
shortage of library for science[@]	.602	.532	-.015	.270	
shortage of teacher[@]	.685	-.011	.031	.507	
shortage of computer staff[@]	.626	.084	.113	.406	
shortage of AV for math[@]	.468	.578	.186	.111	

Note: [@] *deleted due to double-loading*

The overall results for the Korean data are summarized in Table 7.32 (below). There are 11 factors extracted at the classroom level in Korea.

Table 7.32 ***School-level factors extracted in Korea***

Item Content	Number of items	Component extracted	KMO & Bartlett's test	Factor Loading range	Factor renamed
School climate	8	1	0.852	0.695-0.811	Educational ethos
Professional development	5	1	0.719	0.507-0.812	Professional development
Student behaviour (Frequency)	13	3	0.858	0.661-0.849 0.588-0.799 0.691-0.753	Low moralef Bullyingf Disrespectf
Student behaviour (Severity)	13	2	0.914	0.695-0.807 0.886-0.889	Low morales Disrespects
Instructional resources	19	4	0.865	0.602-0.787 0.558-0.825 0.746-0.768 0.766-0.776	Science resource Math resource Infra resource Budget

7.2.3.2 South African school-level factors extracted

In the South African data, the results show a slight difference compared to the Korean data as expected. ‘School climate’ has two factors extracted, unlike one factor extracted in the Korean data (Table 7.33, below). Items related to parent or teacher expectation were double-loaded and excluded. Only ‘high expectation’ items by students remained to make up a scale. Interestingly, South African principals tested distinguish students’ view from their teachers and parents, in contrast to South African teacher tested, to distinguish them from students and parents. A possible explanation is that the South African principals consider that students differ from the expectations of their teachers and parents.

Table 7.33 ***School climate in South Africa***

Items	**Component**		**Factor renamed**
	1	**2**	
teacher job satisfaction-p	**.683**	.182	Professional teaching force
teacher understand goals	**.777**	.160	
teacher degree of success	**.840**	.107	
student regard school	.099	**.826**	High expectation
student desire do well	.198	**.837**	
teacher expect student@	.573	.355	
parent support student@	.570	.512	
parent involve school@	.477	.562	

Note: @ deleted due to double-loading

Professional development is designed for teachers to improve teaching practice and ultimately to improve student achievement. ‘Professional development’ has one factor extracted, as in Korea, without excluding any item (Table 7.34):

Table 7.34 ***Professional development in South Africa***

Items	Component	Factor renamed
	1	
develop curriculum	**.774**	Professional development
develop school goal	**.879**	
develop content knowledge	**.877**	
develop teaching skill	**.882**	
develop ICT	**.740**	

The ‘student behaviour’ question shows a similar picture to that of Korea (Table 7.35). Items related to ‘frequencies’ were loaded on three factors, and they were defined using the same names as in Korea, namely ‘low moralef’, ‘bullyingf’, and ‘disrespectf’. However, of more interest in South Africa is that the first factor extracted in the data is ‘bullying’, as opposed to ‘low morale’ in the Korean data. A possible explanation for this difference is that ‘low morale’ is considered a bigger challenge in Korean schools than ‘bullying’, whereas ‘bullying’ in South African schools is a challenge. Some of the items were double-loaded, or loaded on a different factor from Korea. The ‘cheating’ item shows double-loading in both countries, and thus was deleted in further analysis. Four more items were excluded due to being double-loaded (Table 7.35).

Table 7.35 ***Student behaviour (frequencies) in South Africa***

Items	Component			Factor renamed
	1	2	3	
frequency of profanity	**.737**	.307	-.091	Bullyingf
frequency of vandalism	**.730**	.169	.125	
frequency of theft	**.787**	.147	.123	
frequency of intimidating student	**.795**	.198	.139	
frequency of injury to student	**.665**	.068	.275	
frequency of late arrival	.085	**.807**	.096	Low moralef
frequency of absenteeism	.105	**.864**	.050	
frequency of injury to teacher	.035	.044	**.904**	Disrespectf
frequency of disturbance@	.607	.416	-.070	
frequency of cheating@	.527	.407	.032	
frequency of dress code@	.448	.610	.020	
frequency of skipping@	.427	.685	.035	
frequency of intimidating teacher@	.513	.116	.549	

Note: @ *deleted due to double-loading*

Items of ‘severity’ were also loaded on three factors (Table 7.36), and the loadings show a clear picture, unlike the Korean data which resulted in many items being double-loaded on two factors. As expected from the result of ‘frequencies’, the factor loaded with items relating to bullying behaviour was extracted first. This reinforces the aforementioned claim that bullying behaviour is considered a greater challenge in South African schools than low morale.

Table 7.36 ***Student behaviour (severity) in South Africa***

Items	**Component**			**Factor renamed**
	1	**2**	**3**	
severity of profanity	**.690**	.199	.191	Bullyings
severity of vandalism	**.761**	.210	-.108	
severity of theft	**.772**	.165	.176	
severity of intimidating student	**.626**	.206	.365	
severity of injury to student	**.661**	.228	.212	
severity of late arrival	.126	**.778**	.066	Lowmorales
severity of absenteeism	.178	**.793**	-.029	
severity of skipping	.350	**.713**	.148	
severity of dress code	.147	**.751**	.157	
severity of intimidating teacher	.378	.128	**.765**	Disrespects
severity of injury to teacher	.072	.080	**.879**	
severity of disturbance@	.374	.532	.121	
severity of cheating@	.519	.417	.328	

Note: @ *deleted due to double-loading*

The ‘instructional resources’ question shows a simple picture, unlike the Korean data for the same question, and has only two factors extracted (Table 7.37, below). These are related to material and facility respectively, and are defined as such. An item, ‘shortage of handicapped’, was deleted due to low communalities (0.228) and two items are double-loaded on each factor and deleted.

Table 7.37 ***Instructional resources in South Africa***

Items	Component		Factor renamed
	1	**2**	
shortage of computer for math	**.884**	.108	Material resource
shortage of software for math	**.885**	.101	
shortage of calculator for math	**.778**	.348	
shortage of library for math	**.897**	.168	
shortage of AV for math	**.914**	.161	
shortage of computer for science	**.922**	.081	
shortage of software for science	**.949**	.040	
shortage of calculator for science	**.823**	.348	
shortage of library for science	**.892**	.212	
shortage of AV for science	**.925**	.156	
shortage of computer staff	**.844**	.231	
shortage of building and ground	.183	**.776**	Facility resource
shortage of space	.017	**.788**	
shortage of teacher	-.014	**.569**	
shortage of material	.206	**.687**	
shortage of budget	.277	**.684**	
shortage for handicapped[#]	.427	.215	
shortage of lab equipment[@]	.682	.412	
shortage of heat/cool and light[@]	.445	.604	

Note: [@] *deleted due to double-loading*
[#] *deleted due to low communalities*

The overall results for South Africa are summarized in Table 7.38 (below). There are 11 factors extracted at the school level, some of which are analyzed to ascertain that items to make up one scale have internal consistency.

Table 7.38 ***School-level factors extracted in South African data***

Item Content	Number of items	Component extracted	KMO & Bartlett's test	Factor Loading range	Factor renamed
School climate	8	2	0.834	0.573-0.840 0.512-0.837	Professional teaching force High expectation
Professional development	5	1	0.834	0.740-0.882	Professional development
Student behaviour (Frequency)	13	3	0.886	0.527-0.795 0.610-0.864 0.549-0.904	Bullyingf Low moralef Disrespectf
Student behaviour (Severity)	13	3	0.873	0.519-0.772 0.532-0.793 0.765-0.879	Bullyings Lowmorales Disrespects
Instructional resources	19	2	0.918	0.682-0.949 0.569-0.788	Material resource Facility resource

Factor analysis was carried out on the items of each level, as described up to the point. During the process of selection for inclusion in a factor, the researcher used not only numerical factor loadings as a statistical cut-off but also consulted the conceptual framework developed and presented in Chapter 4. Cohen et al. (2007, p.568) argue that ‘factor analysis is an art as well as a science’, with researchers finding items with the highest values of factor loadings, and including those in a factor. The items chosen should not only have high loadings but are also close to each other conceptually, with some numerical distance from the other items.

As a result, the factor analysis extracted ten factors at the student level, 22 at the classroom level, and 11 at the school level for the Korean data. The factors extracted have been explained and discussed above. Regarding South Africa, ten factors were extracted at the student level, 22 at the classroom level, and 11 at the school level. That the results of factor analysis are different in the two countries may indicate that underlying patterns of the items sought are different, as expected (Cohen et al., 2007). The next step is to run the reliability analysis of the extracted factors, including “yes/no” format questions, to see if they have internal consistency to make up one scale.

7.3 RELIABILITY ANALYSES

Once the items were selected according to factor analysis, it was important to confirm the reliability of a scale consisting of the items extracted. Reliability analysis was carried out for these items. It is said that a factor is reliable when it has an alpha coefficient of at least 0.65 (DeVillis, 1991). Nonetheless, because the current study is exploratory, 0.5 is acceptable (Howie, 2002). Besides alpha coefficients, ‘Corrected Item-Total Correlation’ and ‘Alpha if item deleted’ were examined as a means of selection.

7.3.1 STUDENT LEVEL

At student level in Korea, factors extracted from the factor analysis conducted in the previous section were examined to see if they had internal consistency to build a sound construct. Factors or scales that consist of two or less items were not carried out for reliability analysis. In addition, reliability analyses were carried out on dichotomous format (yes/no) questions. This was the case with ‘home possession’ and ‘safety in school’. The results of the reliability analysis for student data in Korea are described in Table 7.39:

Table 7.39 ***Reliability Coefficients at the student level for Korea***

Contents in TIMSS	Factors	Alpha coefficient	Number of items
Home possession	Home possession	0.403	4
Liking science	Liking science	0.859	7
Valuing science	Valuing science	0.814	5
Learning activities	Practical learning	0.770	4
Learning activities	STS learning	0.619	3
Learning activities	Lecture learning	NA	1
Computers	Computer use	0.720	3
School climate	Liking school	0.704	4
Safety in school	Safe school	0.596	5
Out-of-school act	Play after school	0.636	3
Out-of-school act	Study after school	NA	2

Note: NA non applicable due to one or two items contained

‘Home possession’ consists of 16 sub-items, and although the factor analysis supports a factor ‘home possession’ conceptually, it was excluded in the factor analyses as it is not Likert scale, but “yes/no” format. Even after examining reliability analysis, ‘home possession’ was excluded for further study since the reliability coefficient was still too low (see Appendix G).

Regarding learning activities, ‘STS learning’ only has three items remaining, as two items were deleted due to low communalities (in Section7.2) and low Corrected Item-Total Correlation values respectively. Nonetheless, it still shows a meaningful alpha coefficient, 0.619. On the other hand, ‘play after school’ also has three items because one item, ‘play with friend’, was deleted due to low

Corrected Item-Total Correlation value (0.281) and alpha value of 0.636 (see Appendix G).

As seen in Table 7.39 (above), factors examined satisfied the criterion value, which is Cronbach alpha=0.5, even though most of the factors consist of a few items that remained.

The results of reliability analyses for South Africa are depicted in Table 7.40:

Table 7.40 ***Reliability Coefficients at the student level for South Africa***

Contents in TIMSS	Factors	Cronbach Alpha	Number of items
Home possession	Home possession	0.794	11
Liking science	Enjoying science	0.696	4
Liking science	Self-confidence	0.602	3
Valuing science	Valuing science	0.796	4
Learning activities	Inquiry learning	0.697	5
Learning activities	Lecture learning	0.528	3
Learning activities	Student learning	NA	2
School climate	Liking school	0.803	4
Safety in school	Safe school	0.502	4
Out-of-school act	Study after school	0.650	3
Out-of-school act	Media	NA	1

Note: NA non applicable due to one or two items contained

Unlike the Korean results, ‘home possession’ consists of 11 items after five items were deleted due to low Corrected Item-Total Correlation value. The remaining items show a high alpha coefficient (0.794). ‘Safe school’ consists of five sub-items and a “yes/no” format. Only one item, ‘mine was stolen’, was excluded due to low Corrected Item-Total Correlation. ‘Safe school’ was discussed in more detail, along with ‘school environment’ at the classroom level (see Appendix H).

As was the case in Korea, although some of the factors or scales examined here were as few as three or four, most show statistically significant alpha coefficients, above 0.5.

7.3.2 CLASSROOM LEVEL

All factors at classroom level in Korea, except for one, 'knowledge practice', resulted in alpha values above 0.5 (Table 7.41, below). 'Inquiry practice' has an item with low Corrected Item-Total Correlation and consists of three items to make up a scale excluding the item. It is however worthwhile looking into a question related to OTL (opportunity to learn). 'OTL-physics' consists of only 9 items, with one item showing low item-total correlation having been deleted. 'OTL-chemistry' includes six items, after deleting two items due to low item-total correlation (see Appendix G).

Table 7.41 ***Reliability Coefficients at the classroom level for Korea***

Contents in TIMSS	Factors	Alpha coefficient	Number of item
Preparation to teach	Pchemistry	0.933	5
Preparation to teach	Pphysics	0.913	5
Preparation to teach	Pbiology	0.881	5
Preparation to teach	Penvironment	0.922	3
Preparation to teach	Pearth science	0.866	3
Teacher interaction	Inform-interaction	NA	2
Teacher interaction	Visit-interaction	NA	2
Professional development	Professional development	0.800	6
Attitudes towards subject	Inquiry practice	0.602	3
Attitudes towards subject	Knowledge practice	0.489	3
Attitudes towards subject	Abstract practice	NA	2
School setting	School environment	0.614	4
School climate	High expectation	0.854	5
School climate	Professional teaching force	0.720	3
Content-related activities	STS work	0.687	3
Content-related activities	Practical work	NA	2
Content-related activities	Inquiry work	NA	2
Factors limiting teaching	Student resource	0.831	6
Factors limiting teaching	Physical resource	0.796	3
Factors limiting teaching	Computer resource	0.792	3
Topic coverage	OTL-physics	0.811	9
Topic coverage	OTL-chemistry	0.794	8
Topic coverage	OTL-earth science	0.827	11
Topic coverage	OTL-biology	0.766	12
Topic coverage	OTL-environment	0.860	3
Type of homework	Knowledge homework	0.507	3
Type of homework	Inquiry homework	NA	2
Type of homework	Project homework	NA	1

Note: NA non applicable due to one or two items contained

For South Africa, there was no factor that resulted in an alpha coefficient below 0.5, except for one: 'use of homework' (extensive use). Related to OTL, 'OTL-biology' consists of 11 items after deleting one item due to low item-total correlation (See Appendix G). As shown in Table 7.42 (below), the rest that satisfy a criterion for selection were kept for further analysis.

Table 7.42 ***Reliability Coefficients at the classroom level for South Africa***

Contents in TIMSS	Factors	Alpha coefficient	Number of item
Preparation to teach	Pphysics & Chemistry	0.933	10
Preparation to teach	Pearth science & environment	0.916	6
Preparation to teach	Pbiology	0.904	5
Teacher interaction	Inform-interaction	NA	2
Teacher interaction	Visit-interaction	NA	2
Professional development	Professional development	0.747	6
Attitudes towards subject	Inquiry practice	0.576	4
Attitudes towards subject	Knowledge practice	NA	1
Attitudes towards subject	Abstract practice	NA	1
School setting	School environment	0.860	3
School climate	High expectation	0.842	4
School climate	Professional teaching force	0.758	4
Content-related activities	STS work	0.671	4
Content-related activities	Practical work	NA	2
Content-related activities	Inquiry work	0.519	3
Factors limiting teaching	Physical resource	0.824	5
Factors limiting teaching	Computer resource	0.948	3
Factors limiting teaching	Student morale	0.809	3
Factors limiting teaching	Student SES	NA	2
Topic coverage	OTL-physics	0.773	10
Topic coverage	OTL-chemistry	0.742	8
Topic coverage	OTL-biology	0.770	11
Topic coverage	OTL-earth science	0.875	11
Topic coverage	OTL-environment	0.742	3
Type of homework	Inquiry homework	0.567	3
Type of homework	Knowledge homework	NA	2
Use of homework	Basic homework	NA	2
Use of homework	Extensive homework	0.478	3

Note: NA non applicable due to one or two items contained

7.3.3 SCHOOL LEVEL

In Korea, most of the factors kept at the school level resulted in high alpha coefficients (Table 7.43, below). A single factor, 'parent involvement', turned out an alpha coefficient below 0.5, 0.341. All items of the factor have low Corrected

Item-Total Correlation values below 0.3 (see Appendix G). Therefore, it was excluded from further discussion. The remaining factors examined showed a high alpha coefficient, above 0.7, and accordingly were included for further analysis.

Table 7.43 ***Reliability Coefficients at the school level for Korea***

Contents in TIMSS	Factors	Alpha coefficient	Number of items
School climate	Educational atmosphere	0.898	8
Parent involvement	Parent involvement	0.341	4
Professional development	Professional development	0.721	4
Student behaviour (Frequency)	Low moralef	0.815	5
Student behaviour (Frequency)	Bullyingf	0.805	5
Student behaviour (Frequency)	Disrespectf	NA	2
Student behaviour (Severity)	Low morales	0.848	5
Student behaviour (Severity)	Disrespects	NA	2
Instructional resources	Science resource	0.901	4
Instructional resources	Math resource	0.831	6
Instructional resources	Infra resource	0.761	3
Instructional resources	Budget	NA	2

Note: NA non applicable due to one or two items contained

For South Africa, reliability coefficients of the data are shown in Table 7.44 (below). No factor was found with an alpha coefficient below 0.5, so all the factors examined here were kept for the next analysis, as in the Korean case.

Table 7.44 ***Reliability Coefficients at the school level for South Africa***

Contents in TIMSS	Factors	Alpha coefficient	Number of items
School climate	Professional teaching force	0.750	3
School climate	High expectation	NA	2
Parent involvement	Parent involvement	0.525	3
Professional development	Professional development	0.886	5
Student behaviour (Frequency)	Bullyingf	0.846	5
Student behaviour (Frequency)	Low moralef	NA	2
Student behaviour (Frequency)	Disrespectf	NA	1
Student behaviour (Severity)	Bullyings	0.814	5
Student behaviour (Severity)	Low morales	0.813	4
Student behaviour (Severity)	Disrespects	NA	1
Instructional resources	Material resource	0.977	11
Instructional resources	Facility resource	0.780	5

Note: NA non applicable due to one or two items contained

In order to see if the selected items were consistent to make up one scale, reliability analysis was carried out, as described up to this point. Finally, all scales or factors, including the questions analysed in advance, were examined by means of correlation analysis, to ascertain the relationships with student achievement in science.

7.4 CORRELATION ANALYSES

As the last stage of preliminary analyses, correlation analyses were carried out for the scales or factors identified up to this point. Items consisting of a question were previously examined in terms of factor analysis and reliability analysis. Once it was confirmed that the items underlie one construct and have internal consistency, they were put together to comprise one scale. Next, variable names and labels were assigned for further analysis, and these scales were re-examined by means of correlation analysis. In addition, single-item factors considered important to student achievement from a conceptual point of view were investigated in terms of correlation analysis.

First, the bivariate correlations were examined between the scales or single-item factors and science achievement (see Appendix I and J). Next, the inter-correlations were analyzed between the scales or single-item factors. The inter-correlations were explored to identify whether mulitcollinearity, which is an assumption for regression analysis, was present. The bivariate Pearson product-moment correlation coefficient γ was calculated. The scales or single-item factors that have a correlation coefficient of an absolute value above 0.15 are described and discussed in the following sections. This cut-off point for exploration, not for inclusion for further analyses, was chosen to preliminarily identify possible relationships with science achievement as it was used in some exploratory research previously conducted (Bos, 2002; Howie, 2002). The variance explained also has to be considered, to ascertain how much variance is shared. The variance explained is calculated by squaring and multiplying γ value by 100 to make a change into percentage of variance (Cohen et al., 2007).

7.4.1 STUDENT LEVEL

The results of correlation analyses were explored, starting from the student level of Korea to South Africa. In addition, comparison between the two countries was made, corresponding to factors examined, and helping to answer the first research question.

7.4.1.1 Correlation coefficients for Korea

Korean factors identified as correlation coefficient above 0.15 were described in Table 7.45 (below). Among factors extracted from factor analyses and confirmed from reliability analyses, some factors such as 'liking school' (γ=0.074), or 'safe school' (γ=0.04) showed low correlation and are not shown here. Among single-item factors which were not examined in factor and reliability analyses, some such as 'books at home', 'father education', 'mother education', and 'extra tutor in science' show significant relationships with science achievement (Table 7.45):

Table 7.45 ***Correlation Coefficients at the student level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Books in the home	Books at home	0.381(**)	15
Parents' education	Father education	0.260(**)	7
Parents' education	Mother education	0.236(**)	6
Educational expectations	Student education	0.365(**)	13
Liking science	Liking science	0.407(**)	17
Valuing science	Valuing science	0.340(**)	12
Learning activities in science	Practical learning	0.163(**)	3
Learning activities in science	STS learning	0.198(**)	4
Learning activities in science	Lecture learning	0.253(**)	6
Computers	Computer use	0.206(**)	4
Out-of-school activities	Play after school	-0.226(**)	5
Out-of-school activities	Study after school	0.272(**)	7
Extra lessons/ tutoring	Extra tutor in science	0.177(**)	3

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

Of most significance is that students' attitudes towards science identified 'liking science', or 'valuing science'. As expected, the more students spent their after-school time on playing computer games or watching television the less they performed, and vice versa. By contrast, the more students used computers for activities concerning learning, the better they performed. Second in significance was educational environment, such as 'books at home' or 'parent education level', concurring with previous research. 'Extra tutoring in science', which is common for Korean students, positively influences student achievement in science. All activities on learning science are important and lecture-centred learning is perceived by students as the strongest predictor among them. This result has been controversial in the research field related to teaching strategy. Lecture-centred or teacher-centred strategy is considered as not promoting students' higher-order thinking ability or intellectual development. However, researchers recently started focusing on the efficiency of direct instruction in terms of student achievement (Scheerens & Bosker, 1997; Schroeder et al., 2007).

In terms of variance explained, for Korea, the percentage of variance explained ranges from 3% to 17% as seen in Table 7.45. It is contended that although only 4% of the variance is shared, it cannot be ignored in large-sampled and exploratory studies (Cohen et al., 2007). As expected from correlation coefficients, 'liking science' explained variance in science achievement up to 17%.

7.4.1.2 Correlation coefficients for South Africa

The correlation results for South Africa are presented in Table 7.46 (below). Some factors that were not significant in Korea turned out to be so in South Africa. This was the case with student-background factors such as 'age', 'language', 'family number', or 'born-in country'. As expected from the study previously carried out (Howie, 2002; Howie et al., 2008), student language showed a strong correlation in South Africa. As was the case in Korea, students' attitudes towards science such as 'self-confidence' showed a high correlation. Concurring with the previous finding, the safer schools produced the better performances.

Table 7.46 ***Correlation Coefficients at the student level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Age	Student age	0.318(**)	10
Language	Language at home	0.447(**)	20
Books in the home	Books at home	0.213(**)	5
Home possessions	Home possession	0.475(**)	23
Liking science	Self-confidence	0.384(**)	15
Safety in school	Safe school	0.351(**)	12
Out-of-school activities	Mass media	0.274(**)	8
Extra lessons/ tutoring	Extra science	-0.377(**)	14
Persons living in home	People at home	-0.152(**)	2
Student born in country	Born-in country	0.355(**)	13

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

There are some findings in South Africa that differ not only from Korean results but also from conventional concepts. According to Walberg's productivity model, which includes learners' biological development as one of effective factors, the older the students the better they perform. Student age in South Africa however has a positive relationship with achievement and, given that the younger age was coded with the higher score, it means that the older the student the less well they performed. This finding in South Africa might indicate either that old students repeat grades because they failed to pass the standard demand in light of the curriculum, or that students from educationally and economically poor-resourced homes go to school later than supposed (Mzamane & Berkowitz, 2002, Fiske & Ladd, 2004).

A finding of more interest is that in South Africa there is a positive relationship between 'mass media' as an out-of-school activity and science achievement, as opposed to a negative and stronger relationship in Korea. 'Mass media' is a single-item factor that is 'watch TV or video'. A possible explanation for this unusual result could be that television or video works in South Africa as an educational resource in which students can learn something conducive to their learning. Walberg (1990) also included mass media environments such as TV or video in nine effective factors that influence students' outcomes.

The final difference from the Korean context is that extra tutoring has a negative correlation with student achievement. A possible explanation for this is that extra tutoring is given to students lagging behind in South African schools. In contrast, a positive relationship between extra lessons and achievement in Korea can be explained by a tendency for students to take extra tutoring to prepare for the next class, more common with high-performing than low-performing students.

In terms of variance explained, for South Africa the percentage of variance explained ranges from 2% to 23% as seen in Table 7.46 (above). Compared to Korea, the identified factors explained the higher percentage of variance in terms of science achievement. The highest percentage of variance explained is 'home possession', accounting for up to 23%, followed by 'language at home' at 20%.

7.4.2 CLASSROOM LEVEL

There are many more factors examined and identified in factor analyses and reliability analyses at classroom level than at other levels, viz. student and school levels. Correlation results however show a slightly different picture between Korea and South Africa.

7.4.2.1 Correlation coefficients for Korea

Although many factors were examined previously, there are as few as four factors significant in Korea (Table 7.47, below). According to the results, the more time or periods to teach science per week are assigned to science teachers, the better the students performed. The number of periods scheduled per week is limited to below 24 in Korean schools, and mostly teachers have either a few more or less than 20. The senior teachers who are in charge of more administrative duties tend to have fewer periods. Taking account of this situation in Korean schools, the finding above supports the claim that if teachers have more teaching duties and fewer other duties, such as administrative duties, they may devote themselves to teaching duties to a greater extent, and thus improving outcomes in students.

Table 7.47 ***Correlation Coefficients at the classroom level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Teaching load	Time scheduled	0.231(**)	5
Teacher interaction	Inform-interaction	0.193(**)	4
School climate	High expectation	0.285(**)	8
Class size	Class size	0.315(**)	10

*Note: ** Correlation is significant at the 0.01 level (2-tailed)*

Consistent with previous findings, teacher interactions based on pedagogy or instructional information helped students' achievement in science. High expectation also shows a strong relationship with student achievement. Importantly, the more students there are in the classroom the better the students perform. A possible explanation for this is that Korean parents who have more educational aspirations for their children would prefer moving to schools with a better educational environment as in Korea a student is allocated to the school located nearest to their house. In particular, before the academic schedule starts it is not uncommon to see people moving to more prestigious school areas, which can lead to some overcrowded classrooms.

In terms of the classroom in Korea, the percentage of variance explained ranges from 4%, which is 'inform-interaction', to 10%, 'class size' (Table 7.47, above). The range gap is as narrow as the number of significant factors. Although it seems low, it is worth examining in terms of a large-sampled exploratory study.

7.4.2.2 Correlation coefficients for South Africa

In contrast to the results of the Korean data, the South African data resulted in more factors influencing student achievement (Table 7.48, below). Of interest, but as expected, is that factors concerning teacher background show a strong relationship with student achievement in South Africa. For example, the more highly educated the teachers the better their students performed. Students whose science teacher was older and more experienced performed better. This point is directly related to preparation to teach, and in particular the more teachers feel ready to teach physics and chemistry contents compared to other areas, the better their students fared in South Africa.

Table 7.48 ***Correlation Coefficients at the classroom level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Age	Teacher age	0.324(**)	11
Teaching experience	Teaching experience	0.320(**)	10
Formal education	Formal education	0.254(**)	7
Teaching requirement	1st degree	0.366(**)	13
Teaching license	License type	0.298(**)	9
Preparation to teach	Pphysics & Chemistry	0.156(*)	2
Teaching load	Time scheduled	0.210(**)	4
Teacher interaction	Visit-interaction	-0.246(**)	6
School setting	School environment	0.301(**)	9
School climate	High expectation	0.173(*)	3
Class size	Class size	-0.282(**)	8
Time spend teaching subject	Science teaching time	-0.209(**)	4
Textbook	Textbook use	-0.293(**)	9
Content-related activities	STS work	-0.262(**)	7
Content-related activities	Practical work	-0.150(*)	2
Factors limiting teaching	Physical resource	-0.489(**)	24
Factors limiting teaching	Computer resource	-0.357(**)	13
Factors limiting teaching	Student SES	-0.230(**)	5
Topic coverage	OTL-biology	-0.181(*)	3
Computer availability	Computer availability	0.412(**)	17
Type of homework	Inquiry homework	-0.185(**)	3
Type of homework	Knowledge homework	-0.188(**)	4
Use of homework	Basic homework	-0.203(**)	4

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

Of greater importance is that some factors show negative relationships with student achievement as opposed to the previous research findings. That was the case for ‘science teaching time’, ‘textbook use’, ‘practical work’, and ‘OTL-biology’. The more minutes a science teacher teaches a class sampled the worse the students’ performance. Textbook use also shows a negative relationship. From the descriptive statistics of the South African data, it is evident that most science teachers use textbooks as a supplementary resource rather than the primary basis for lessons. Textbook-reliant teaching resulted in a worse performance in South Africa. Furthermore, the more biology content covered the less the students performed. The aforementioned findings need further research before they can be used to make any interpretations.

Another negative relationship occurred with colleague interaction. The more teachers interact with their colleagues by observing lessons or visiting classrooms, the worse their students fare. A possible explanation for this may be that observation or visiting by a colleague is used to evaluate teachers in South Africa at the present, rather than improve pedagogy. As was the case in Korea, the greater the teaching load, the better the students performed.

In keeping with the previous research findings, the more the factors limiting teaching science the worse the students perform. Unlike the Korean results, factors describing homework show significant relationships with student achievement in South Africa. The relationship is negative and may reflect a preference amongst teachers to giving and using homework to students who lag behind. Another possible explanation is that teachers with low qualifications prefer giving and using homework as a means of making up their teaching deficit.

As regards teaching practice, ‘STS work’ and ‘practical work’ show a negative relationship. These two teaching practices have been recommended in particular in science classroom. Nonetheless, the negative relationships in South Africa might imply that they are not practiced by teachers properly. Specifically speaking, practical work involves the use of science equipment and, in South Africa, science classrooms tend to be very poorly equipped.

Considering many under-qualified teachers in South Africa reported by literature (Naidoo & Lewin, 1998; Howie, 1999), poorly trained teachers may also use practical work ineffectively. As Hattingh et al. (2007) pointed out in their study, science teachers seem more likely to use practical work to compensate for poor verbal communication in South Africa, where many students study science in a language different from their mother tongue.

In terms of variance explained, for South Africa, the percentage ranges from 2% to 24% (Table 7.48, above). In particular, 'physical resource' explained markedly the variance in science achievement compared to other factors described. Apart from resource-related factors such as 'physical resource' or 'computer availability', teacher background such as 'age', 'teaching experience' and '1st degree' accounted for the variance next to them.

The results revealed that many of variables concerning science instruction were not found to be a strong predictor of student performance. This might imply that factors describing instruction characteristics are difficult to capture by means of a survey-type methodology such as TIMSS (Kupari, 2006).

7.4.3 SCHOOL LEVEL

Correlation analyses at the school level have some similarities and differences between Korea as South Africa, as expected. The details of results are described as follows.

7.4.3.1 Correlation coefficients for Korea

In Korea, size of school and community have significant relationships with student performance (Table 7.49, below). The larger the school and the community the better students perform in science. However, of importance is the finding that the more students bully, the better their achievement. A possible explanation for this is that bullying occurs in larger cities, which show better performance. Another possible explanation is that 2% more boys than girls were tested, with boys outperforming girls by 12 points in Korea (Martin, Mullis, Gonzalez & Chrostowski, 2004), and, generally speaking, bullying is more commonly carried out by boys. Nonetheless, this needs further research before any decisive interpretation can be made.

Table 7.49 ***Correlation Coefficients at the school level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Enrolment	All grades	0.471(**)	22
Enrolment	Eight grade	0.454(**)	21
Type of community	Community size	0.369(**)	14
Students' background	Disadvantaged	-0.509(**)	26
Students' background	Advantaged	0.446(**)	20
School climate	Educational ethos	0.414(**)	17
Professional development	Professional development	0.229(**)	5
Student behaviour	Bullyingf	0.172(*)	3
Student behaviour	Disrespects	-0.154	2
Computer	Computers at school	0.208(*)	4

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

No factor concerning resource was found to be significant in Korea. However, a higher percentage of disadvantaged students and a lower percentage of advantaged students resulted in a worse school performance. Favoured educational ethos and professional development show results consistent with previous findings, as reviewed in chapter 3 (Edmonds, 1979; Scheerens & Bosker, 1997; Mayer et al., 2000; Supovitz et al., 2000). The more computers the school has the better the students performed. Judging from the researcher's experience in Korean schools, the number of computers relates to the size of the school, because there is a computer in each classroom and more computers therefore reflect a larger school.

In Korea the percentage of variance explained ranges from 2% to 26% (Table 7.49, below). Student background named 'disadvantaged' and 'advantaged' accounted for the variance in science achievement from 20% up to 26% and size of school, depending on enrolment explained the variance by 22%.

7.4.3.2 Correlation coefficients for South Africa

In South Africa, there are some significant factors that do not show up in the Korean results (see Table 7.50, below). Such principals' duties as administration, supervising or evaluation had a significant relationship with student performance in keeping with the previous finding as reviewed in chapter 3. In particular, the more involved principals are in supervising or evaluating teachers or staff the worse their students fared. This negative association with achievement seems to have a bearing on teacher interaction with colleagues, by observing lessons or visiting classrooms, as discussed in Section 7.4.2.2. 'Visit to classrooms or observation of the lesson' makes teachers feel they are being supervised or evaluated. However, considering a positive relationship of administrative duty by principals, principals' roles in schools are important in terms of achievement in South Africa.

Table 7.50 ***Correlation Coefficients at the school level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Enrolment	All grade	0.301(**)	9
Enrolment	Eight grade	0.222(**)	5
Type of community	Type of community	0.367(**)	14
Stability of student body	Absenteeism	-0.197(**)	4
Stability of student body	Student still enrolled	0.295(**)	9
Student background	Disadvantaged	-0.616(**)	38
Student background	Advantaged	0.553(**)	31
Student background	1st language	0.609(**)	37
School climate	Professional teaching force	0.302(**)	9
School climate	High expectation	0.209(**)	4
Principals' time allocation	Administrative duty	0.324(**)	11
Principals' time allocation	Supervise & evaluate	-0.230(**)	5
Parent involvement	Parent involvement	-0.159(*)	3
Incentives for teachers	Incentive for science teacher	0.161(*)	3
Student behaviour	Low morales	-0.208(**)	4
Instructional resource	Material resource	-0.182(*)	3
Instructional resource	Facility resource	-0.442(**)	20

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

Importantly, the more the schools expected parents to attend special events, volunteer for school projects and programmes, or serve on school committees, the worse the students performed. Parent's social involvement with schools may reflect social rather than academic expactations, leading to lower student performance. It was also found that when schools use incentives to recruit or retain science teachers, the students performed better. This may be an indication of a school's culture of learning.

Student-background factors such as 'absenteeism', 'student still enrolled', 'the percentage of the disadvantaged students', or '1st language' are important. As expected, resource-related factors show negative relationships with student achievement in South Africa as well. 'Professional teaching force' and 'high expectation' show positive relationships with achievement, in common with other many studies.

With respect of variance explained at the school level for South Africa, it is noteworthy that there is the highest percentage of variance explained in science achievement ranging from 3% to 38% (Table 7.50, above). The results show that factors related to student background, such as 'disadvantage', 'advantaged', or '1st language', accounted for more than 30% of the variation in achievement. Notably, 'facility resource' consisting of building, ground, space, teacher, and budget influenced student achievement more than 'material resource' in South Africa.

As seen in all the results above, some of the factors are paralleled conceptually or across the levels. To make the model for further analysis economical they were screened to make a decision of inclusion, presented in the next section.

7.5 SELECTION OF VARIABLES

From factor analyses, there are ten factors extracted at the student level, 22 factors at the classroom level, and 11 factors at the school level for the Korean and the South African data respectively.

According to the results of reliability analyses, there are eight factors identified at the student level, 20 at the classroom, and eight factors at the school for Korea. As for South Africa, nine factors were examined at the student level, 19 at the classroom level, and eight at the school level.

Thereafter, correlation analyses identified 13 factors at the student level, four at the classroom level, and ten at the school level for Korea. There are ten student-level factors, 23 classroom-level factors, and 17 school-level factors with strong relationships with student achievement in South Africa.

Among factors mentioned above, the selection of variables for further analysis was made. The criterion for inclusion for further analyses was based on the strength of the correlations and was above 0.2, and their significance (0.99 confidence interval), which is stricter than in the preliminary analysis. From a general point of view, where the coefficient is below 0.35, the relationship is low. However it is justifiable considering that current research involves a large-sampled exploratory study where correlations ranging from 0.20 to 0.35 may be slightly statistically significant and valuable enough to explore the interconnection of variables (Howie, 2002; Cohen et al., 2007; Scherman, 2007; Creswell, 2008).

Multicollinearity was examined across these selected factors. Multicollinearity exists when variables are highly correlated with each other and thus measure the same construct (Miles & Shevlin, 2001) (‘factor’ is interchangeable with ‘variable’ but hereafter referred to as ‘variables’). Multicollinearity may exaggerate the variances of the parameter estimates in a study of which the purpose is to estimate the contributions of individual predictors (Rawlings, 1988). Therefore, factors for which multicollinearity was a consideration were identified and removed from the study. There are many ways to assess multicolinearity among the variables, such as examining tolerance, the correlations between variables, or the variance inflation factor (VIF) (Miles & Shevlin, 2001). Literature indicates that anything above 0.6 should be explored further and anything above 0.8 should be excluded due to multicollinerarity considerations (Scherman, 2007).

In order to make a more appropriate selection of the scales or factors, it was also considered whether the factors make sense conceptually from the perspective of the research framework. Another point of importance is that researcher should be parsimonious with factors. At least 10 observations per variable are recommendable to use for analysis purposes as a general rule of thumb (Field, 2005).

7.5.1 STUDENT LEVEL

First, at the student level, the results of the two countries were examined to select variables for inclusion in the multilevel analyses. The selection of factors was based on the analysis above, as well as the conceptual framework. For example, ‘father education’ and ‘mother education’ are almost the same constructs, therefore ‘father education’, with a higher correlation, remained in the Korean data. This holds for ‘play after school’ and ‘study after school’, ‘liking science’ and ‘valuing science’.

Despite the correlation value below 0.2, ‘extra tutoring’ was selected because it is important in terms of ‘time on task’ and in particular in Korea, ‘extra tutoring’ becomes more common. Accordingly, it is causing students to over-burden study loading and imposes a greater economic burden upon their parents.

Table 7.51 ***Factors selected at the student level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Books in the home	Books at home	0.381(**)	15
Parents' education	Father education	0.260(**)	7
Educational expectations	Student education	0.365(**)	13
Liking science	Liking science	0.406(**)	17
Learning activities in science	Lecture learning	0.253(**)	6
Computers	Computer use	0.206(**)	4
Out-of-school activities	Study after school	0.272(**)	7
Extra lessons/ tutoring	Extra tutoring	0.176(**)	3

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

On the other hand, although data about learning activities in science was collected at the student level, that on 'lecture learning' in particular was aggregated to be included at the classroom level because it is more likely to represent the teaching practice by teachers. Hereafter, this variable is shown at the classroom level. Data concerning teaching practice was also collected parallel to the classroom level, e.g., content-related activities, but it did not show anything of importance in terms of student achievement, even though research has proven the importance of teaching strategy (Wise 1996; Scheerens & Bosker, 1997). Therefore, the variable was derived from the student level. The factors finally selected in the Korean data are presented in Table 7.51 (above).

Table 7.52 ***Factors selected at the student level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Age	Student age	0.318(**)	10
Language	Language at home	0.447(**)	20
Books in the home	Books at home	0.213(**)	5
Home possessions	Home possession	0.475(**)	23
Liking science	Self-confidence	0.384(**)	15
Safety in school	Safe school	0.351(**)	12
Out-of school activities	Mass media	0.274(**)	8
Extra lessons/ tutoring	Extra tutoring	-0.377(**)	14
Student born in country	Born-in country	0.355(**)	13

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

For South Africa (see Table 7.52, above), 'safe school' is paralleled with 'school environment' at the classroom level in a broad sense. Because the concept is more related to the overall school environment, the factor was aggregated into the classroom level and hereafter this variable shows at the classroom level. If data is aggregated, Hox (2002) points out two problems encountered, which are statistical and conceptual. The data aggregated leads to much information being lost and thus statistical power of analysis is lost. Furthermore, when interpreting the aggregated data at the lower level, ‘ecological fallacy’ might occur due to the difference between the correlation coefficients from different levels (Hox, 2002, p.4).

Nonetheless, the current study used the aggregated data, since that such as students’ self-perceptions reflect a specific country’s educational, cultural, and social contexts as well as individual characteristics (Shen & Tam, 2008). Judging from the researcher’s experience in secondary schools, students tend to take safety in school more seriously than do teachers. In conclusion, all the factors with a correlation coefficient above 0.2 were kept for the next analysis (Table 7.52, above).

7.5.2 CLASSROOM LEVEL

For the Korean data, all factors drawn from the correlation analysis were kept for further analyses. In particular, despite a relatively weak correlation, inform-interaction remained because significant factors included are sparse at the classroom level and are important in terms of teachers’ professional development. The results of selection for Korea are presented in Table 7.53:

Table 7.53 ***Factors selected at the classroom level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Teaching load	Time scheduled	0.231(**)	5
Teacher interaction	Inform-interaction	0.193(**)	4
School climate	High expectation	0.285(**)	8
Student No. in classroom	Class size	0.315(**)	10

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

In South Africa, there is a need to reduce factors in order to make variables parsimonious or economical. From a perspective of the current research framework, if factors represent the same or similar construct, among them the single factor that has stronger correlation value was kept and the others were excluded. Such was the case for teacher qualification and resource-related factors. As a result, 'teacher age' remained and 'teaching experience' was left out. 'Formal education' and 'license type' were excluded, and '1st degree' was kept for further analyses.

Table 7.54 ***Factors selected at the classroom level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Age	Teacher age	0.324(**)	11
Teaching requirement	1st degree	0.366(**)	13
Teaching load	Time scheduled	0.210(**)	4
Teacher interaction	Visit-interaction	-0.246(**)	6
School setting	School environment	0.301(**)	9
Student No. in classroom	Class size	-0.282(**)	8
Time spend teaching subject	Science teaching time	-0.209(**)	4
Textbook	Textbook use	-0.293(**)	9
Content-related activities	STS work	-0.262(**)	7
Factors limiting teaching	Physical resource	-0.489(**)	24
Use of homework	Basic homework	-0.203(**)	4

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

In particular, resource-related factors not only represent the same or similar constructs, but also are paralleled with the student level or the school level. In order to make a built model parsimonious, 'physical resource' only remained at the classroom level. Accordingly, resource-related factors such as 'student SES' and 'computer resource' were excluded from further analyses. Another paralleled factor, 'school environment', is similar to 'safe school' at the student level. In this case, the factors at the lower level were kept and the same factors at higher level were excluded from further analysis because it is considered that the responses from the lower level tend to be more specific and practical. This holds for 'high expectation' (γ=0.285) at the classroom level and 'educational ethos' (γ=0.414) at the school level in Korea.

Although computer availability in science lessons shows a strong relationship (0.412), because it is highly similar to other resource-related factors, it was excluded from further analysis. Ultimately, the factors kept for the next analysis are shown in Table 7.54 (above).

7.5.3 SCHOOL LEVEL

Firstly, a closer look at the Korean results taken, enrolment of all grades including Grade 8, and the number of computers represents the same construct, which is school size. The number of computers in a school depends largely on school size because the government offers computers for every classroom and teacher. Therefore, enrolment of all grades only remained for further analysis. Similarly, the percentage of disadvantaged students remained and percentage of advantaged student was excluded.

Table 7.55 ***Factors selected at the school level for Korea***

Contents in TIMSS	Factors	Correlation	% variance explained
Enrolment	All grades	0.471(**)	22
Type of community	Community size	0.369(**)	14
Students' background	Disadvantaged	-0.509(**)	26
School climate	Educational ethos	0.414(**)	17
Professional development	Professional development	0.229(**)	5

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

Likewise, the rules applied in the Korean data hold for the South African data. Students' first language is a parallel item to the student level and the item from the lower level, student level, was selected. 'Student still enrolled' was excluded because it was considered the same construct as percentage of 'the disadvantaged'. Resource-related factors were excluded for the reason mentioned in advance at the classroom level. In addition, since the South African data showed more than 30% missing value with respect to computer use, these items were excluded from further analysis. As a result, the factors kept finally are shown in Table 7.56:

Table 7.56 ***Factors selected at the school level for South Africa***

Contents in TIMSS	Factors	Correlation	% variance explained
Enrolment	All grades	0.301(**)	9
Type of community	Community size	0.367(**)	14
Student background	Disadvantaged	-0.616(**)	38
School climate	Professional teaching force	0.302(**)	9
School climate	High expectation	0.209(**)	4
Principals' time allocation	Administrative duty	0.324(**)	11
Principals' time allocation	Supervise & evaluate	-0.230(**)	5
Student behaviour	Low morales	-0.208(**)	4

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

In summary, seven factors and one aggregated factor at the student level, four factors at the classroom, and four factors at the school level respectively were kept for the inclusion of further analysis in the Korean data. For the South African data, eight factors and one aggregated factor at the student level, ten factors at the classroom level, and eight factors at the school level were kept for the inclusion of further analysis. The factors selected at various levels in Korea and South Africa are summarised in Table 7.57:

Table 7.57 ***Factors selected in the multilevel analyses***

	Student level	Classroom level	School level
Korea	Books at home Father education Student education Liking science Extra tutoring Study after school Computer use	Time scheduled Class size High expectation Inform-interaction Lecture learning*	All grades Community size Disadvantaged Professional development
South Africa	Student age Language at home Books at home Home possession Self-confidence Mass media Born-in country Extra tutoring	Teacher age 1st degree Time scheduled Visit-interaction Class size Science teaching time Textbook use STS work Basic homework Physical resource	All grades Community size Disadvantaged Professional teaching force High expectation Administrative duty Low morales Supervise & evaluate Safe school*

*Note: * Factors that were aggregated from the lower level.*

7.6 CONCLUSION

In this chapter, the results of preliminary analyses were presented and some comparison was taken to answer the main research question. Preliminary analysis involved factor analysis, the computation of reliability, and correlation analysis successively. The factor analyses began with dealing with missing data. Even though mean or median substitution lead to exaggeration of variance, given the current research is exploratory, the concern can be diminished.

Factor analysis identified items that underlie the same construct. From the factor analysis of the Korean data, ten factors were identified at the student level, 22 factors at the classroom level, and 11 factors at the school level. Factor analysis of the South African data found ten factors that were identified at the student level, 22 factors at the classroom level, and 11 factors at the school level.

The resulting scales from principal component analysis which seemed to make sense from a content perspective were analyzed further by calculating the reliability coefficient Cronbach α. Reliabilities were calculated to measure the coherence of the items identified from the factor analysis. Items that lowered alpha coefficients were deleted. Inter-item correlations were also computed to investigate the coherence of the scales. Once items were found to form internally consistent scales from those analyses and to represent the appropriate factors from a perspective of the research framework, the items were retained for further analysis. Reliability computation resulted in most of the items examined having internal consistency to make up one scale except for such factors as ‘home possession’, ‘knowledge practice’, ‘parent involvement’ in Korea, and ‘use of homework’ in South Africa.

The remaining items were then examined by means of correlation analysis. Correlation analysis of the Korean data identified 13 significant scales or single-item factors at the student level, four factors at the classroom level, and ten factors at the school level. On the other hand, correlation analysis resulted in ten significant scales or single-item factors at the student level, 23 factors at the classroom level, and 17 factors at the school level in the South African data at the school at the 0.01 or 0.05 significance level. Ultimately, the scales or factors taken from the results of the correlation analysis were used as the final variables for multilevel analysis.

During the selection of variables, the factors identified above were examined from a perspective of the research framework and were decreased to keep factors from paralleling the construct and to make them parsimonious. Accordingly, eight variables including one aggregated variable at the student level, four variables at the classroom level, and four variables at the school level were retained finally in the Korean data. For South Africa, nine variables including one aggregated variable at the student level, ten variables at the classroom level, and eight variables at the school level were kept at last.

The differences in the outcomes of the preliminary analysis across the two countries regarding the direct effects on science achievement are reflected in the different sets of selected latent variables for multilevel analysis.

CHAPTER 8

RESULTS OF MULTILEVEL ANALYSES

8.1 INTRODUCTION

Multilevel models address the statistical problems involved in simultaneously assessing factors at the classroom or school level and student-level factors operating within an educational context, and have been used in a number of studies (Raudenbush & Bryk, 1997). The multilevel models generated also provide the opportunity to explain why achievement may vary across classrooms or schools and why the individual distribution in achievement also may vary within classrooms (Fuller & Clarke, 1994). Furthermore, the development of multilevel analysis allows comparative researchers to carefully consider the distribution of school and student factors across differing communities, allowing researchers to formally conditionalize (operationalize) empirical findings (Riddell, 1989). This has occurred because of advances in analytic methods that depend on computer speed and processing.

The purpose of this chapter is to explore the extent to which factors at the student, classroom, and school level influence science achievement, and is guided by the main research question, which is: ***To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?***. The question is operationalized by four specific questions, as follows:

1. Which factors influencing achievement are generic when comparing Korea and South Africa?
2. Which factors influencing achievement are specific to Korea?

3. Which factors influencing achievement are specific to South Africa?
4. How do these generic and specific factors explain the difference in the performance of the two countries?

Multilevel analysis is considered appropriate to address these questions as presented in Chapter 1. The results of the preliminary analyses identified factors functioning in each country and factors that have significant correlations with student science achievement. In order to identify the amount of the variance explained, considering the nested structure of the education system, multilevel analysis was carried out applying MLwiN. The analysis aims to show the degree to which the variables of each level explain the variation of student science achievement and which particular factors stand out as statistically significant predictors in the two countries.

Prior to running MLwiN, the preparation of the data and the selection of the variables included in the analysis are described in Section 8.2. Thereafter, the null multi-level model is presented and described in Section 8.3. Consecutively, the first level and second level models including explanatory variables are presented. The proportion of variance is explained and interaction effects follow (Section 8.3.4). In particular, the results of the multilevel analysis are explored, comparing the Korean data with the South Africa data. Finally, the chapter is summarized in Section 8.4.

8.2 PREPARATION OF THE DATA

There are some principles to consider where a model is built based on variables clustered and tested. Bos (2002) argues that items should be clustered keeping valid homogeneity both ‘empirically’ and ‘conceptually’, as stated in Chapter 7. When Howie (2002) studied a multilevel model, she considered both coherence between the conceptual framework and coefficients tested, and the simplicity of a model, which means the model should be parsimonious. Preparation of the data for multilevel analyses took into account those principles presented in Section 8.2.1. The initial model was built on the selected variables in Section 8.2.2 and the full model was developed in Section 8.2.3.

8.2.1 IDENTIFYING VARIABLES TO BE EXPLORED WITH MULTILEVEL ANALYSES

As a result of the factor, reliability, and correlation analyses, the factors were selected for inclusion in the multilevel models. The more detailed selection process at various levels was explored in Section 7.5. Once factors were identified and confirmed from the factor and reliability analyses, correlation analyses were undertaken to identify only significant relationships between factors and achievement to be explored by further analysis. Factors with a correlation coefficient of above 0.2 were identified as possible factors to be included in the multilevel models. In exploratory studies such as the current one, the value of 0.2 cannot be ignored if the sample is large (Cohen et al., 2007). Correlations between the variables selected were also considered to assess mulitcollinearity in the data.

The study used the correlations between variables to assess multicollinearity. Whether or not a variable should be dropped from the investigation is determined by taking into account both the importance of the variables in light of the conceptual framework and the absolute value of γ between variables. Where the correlation coefficient between two or more variables is above 0.6, only one variable among them remained and the rest were excluded. Korean ‘class size’ at the classroom level and ‘enrolment of all grade’ at the school level have a strong correlation, $\gamma=0.637$. Furthermore, judging from the researcher’s experience in Korean secondary schools, a larger school has more students in a classroom than a smaller school. Therefore, ‘class size’, which has a weaker correlation with science achievement, was excluded and ‘enrolment of all grade’ remained. In contrast, multicollinearity does not exist in South African data, possibly due to the many factors having already been excluded during the preliminary selection process.

The conceptual framework was also used for the selection of variables. In terms of the conceptual framework, where two or more variables represent the same construct, only one variable remained and the rest were excluded. For example, in the Korean data, ‘high expectation’ at the class level and ‘educational ethos’ at the school were highly related to each other conceptually. As regards South African data, teacher- and resource-related factors show overlapped constructs, and thus were reduced as the relationships between the factors and science achievement were empirically weak and their meanings conceptually overlapping.

Considering all the above points, 15 variables in the Korean data were identified for the multilevel modelling: eight variables including one aggregated variable at the student level, three variables at the class level, and four variables at the school variables, as presented in Table 8.1:

Table 8.1 ***Correlation coefficients of factors in Korean data***

Level	Contents in TIMSS	Factors	Correlation	% variance explained
Student	Books in the home	Books at home	0.381(**)	15
	Parents' education	Father education[12]	0.260(**)	7
	Educational expectations	Student education	0.365(**)	13
	Liking science	Liking science	0.407(**)	17
	Learning activities in science	Lecture learning	0.253(**)	6
	Computers	Computer use	0.206(**)	4
	Out-of-school activities	Study after school	0.272(**)	7
	Extra lessons/ tutoring	Extra tutor in science[@]	0.177(**)	3
Classroom	Teaching load	Time scheduled	0.231(**)	5
	Teacher interaction	Inform-interaction[@]	0.193(**)	4
	School climate	High expectation	0.285(**)	8
School	Enrolment	All grades	0.471(**)	22
	Type of community	Community size	0.369(**)	14
	Students’ background	Disadvantaged	-0.509(**)	26
	Professional development	Professional development	0.229(**)	5

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*
[@] γ = below 0.2, but included due to the importance

As for South African, 27 variables remained for the multilevel modelling: nine variables including one aggregated variable at the student level, ten variables at

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[12] mother education level also showed a strong relationship with science achievement but not as much as father’ coefficient (see Table 7.45). Accordingly, father education level was selected.

the class level, and eight variables at the school variables, as presented in Table 8.2:

Table 8.2 ***Correlation coefficients of factors in South African data***

Level	Contents in TIMSS	Factors	Correlation	% variance explained
Student	Age	Student age	0.318(**)	10
	Language	Language at home	0.447(**)	20
	Books in the home	Books at home	0.213(**)	5
	Home possessions	Home possession	0.475(**)	23
	Liking science	Self-confidence	0.384(**)	15
	Safety in school	Safe school	0.351(**)	12
	Out-of-school activities	Mass media	0.274(**)	8
	Extra lessons/ tutoring	Extra science	-0.377(**)	14
	Student born in country	Country of birth	0.355(**)	13
Classroom	Age	Teacher age	0.324(**)	11
	Teaching requirement	1st degree	0.366(**)	13
	Teaching load	Time scheduled	0.210(**)	4
	Teacher interaction	Visit-interaction	-0.246(**)	6
	Class size	Class size	-0.282(**)	8
	Time spend teaching subject	Science teaching time	-0.209(**)	4
	Textbook	Textbook use	-0.293(**)	9
	Content-related activities	STS work	-0.262(**)	7
	Factors limiting teaching	Physical resource	-0.489(**)	24
	Use of homework	Basic homework	-0.203(**)	4
School	Enrolment	All grade	0.301(**)	9
	Type of community	Type of community	0.367(**)	14
	Student background	Disadvantaged	-0.616(**)	38
	School climate	Professional teaching force	0.302(**)	9
	School climate	High expectation	0.209(**)	4
	Principals' time allocation	Administrative duty	0.324(**)	11
	Principals' time allocation	Supervise & evaluate	-0.230(**)	5
	Student behaviour	Low morales	-0.208(**)	4

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

There is a large discrepancy in the number of factors, in particular at the class and school level. A possible explanation for this might be that more factors at the class and school level influence student achievement in South Africa than in Korea. The descriptive statistics of the variables retained are presented in Tables 8.3 and 8.4, for Korea and South Africa respectively:

Table 8.3 ***The Korean variables included in MLwiN***

Factors in the research framework	Variable in preliminary analysis	Variable in MLwiN	Description of variables	N	Mean[13]	SD	Range
Time on task	Tutorsci	Extutor	Extra tutoring in science	4876	1.51	1.33	0-3(3)
	Studyafsch	Timafsch	Study after school	4876	2.40	1.32	0-8(8)
Attitude toward science	Likescience	Liksci	Liking science	4876	16.67	4.12	7-28(21)
Social context	Bookhom	Bokhom	Books at home	4876	3.21	1.28	1-5(4)
	Edudad	Edudad	Education level of father	4876	5.13	1.65	1-8(7)
	Edustu	Edustu	School level expected by student	4876	3.99	0.74	1-5(4)
	Comuse	Comuse#	Computer use	4876	4.73	2.44	0-12(12)
Teacher background	Tchtotchpm	Tchtchpm#	Teacher interaction by information or pedagogy	137	2.80	1.26	0-6(6)
Teaching practice	Lectureag	lecturag*#	Lecture-centred teaching	137	2.39	0.22	1.66-2.8(1.14)
Classroom climate	Hixpect	Hixpect	High expectation	137	15.28	2.80	8-24(16)
Time for learning	Ttimew	Timspw#	Time scheduled/week	137	2.25	0.37	1.5-3.5(2)
Professional teaching force	Profdevelop	Profdeve	Professional development	137	4.48	1.65	1-10(9)
School climate	Enrtot	Schsize	Enrolment of all grades	137	4.25	1.36	1-7(6)
	Citysize	Citysize#	Type of community	137	5.05	1.21	1-6(5)
	Studis	Disadva	Percentage of disadvantaged students	137	2.01	0.91	1-4(3)

Note: * *aggregated variable*
non-significant variables according to the multilevel analysis

The variables as shown in Tables 8.3 and 8.4 were grouped under the factors defined in the conceptual framework. More specifically, the variables selected were classified in terms of the conceptual framework of the research, of which key concepts are ‘quality’, ‘time’, and ‘opportunity’. Instructional quality at the classroom level is classified with ‘teacher background’, ‘science curriculum’, ‘teaching practice’, ‘classroom climate’, and ‘physical resource’. Quality at the school level is specified with ‘curriculum management’, ‘professional teaching force’, ‘school climate’, and ‘resource’.

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[13] The options of items were recoded within each range shown in the Table and ‘Mean’ value is the average of scores recoded. This holds for the ‘Mean’ of Table 8.4.

Table 8.4 *The South African variables included in MLwiN*

Factors in the research framework	Variable in preliminary analysis	Variable in MLwiN	Description of variables	N	Mean	SD	Range
Time on task	Tutorsci	Extutor	Extra tutoring in science	6784	1.47	1.09	0-3(3)
Attitude toward science	Selfconsci	Selfcon	Self-confidence in science	6784	7.41	2.42	3-12(9)
Social context	Agesy	Agestu	Student age	6784	3.26	1.20	1-5(4)
	Stucon	Boncnty	Country of birth	6784	0.65	0.48	0-1(1)
	Languas	Languag	Student language at home	6784	1.33	0.94	0-3(3)
	Bookhom	Bokhom[@]	Books at home	6784	1.97	1.13	1-5(4)
	Hompos	Hompos	Home possession	6784	6.13	2.99	0-11(11)
	Watvi	Media	Watch TV or video after school	6784	1.67	1.41	0-4(4)
Science curriculum	Textuse	Textuse	Textbook use	198	0.92	0.27	0-1(1)
Teacher background	Agetcher	Agetch	Teacher age	198	3.05	0.82	1-5(4)
	Reqgrad	1stdeg	Complete the first degree	198	0.18	0.38	0-1(1)
	Tchtotchvo	Tchtchvo[#]	Interaction by visit or observation	198	1.20	1.45	0-6(6)
Teaching practice	Useofhw	Basichw[#]	Use of homework(basic homework)	198	3.72	0.60	1-4(3)
	STS	STS	STS-centred teaching	198	7.13	2.40	2-12(10)
Physical resources	Phyresource	Phyres	Physical resource for science lesson	198	9.94	4.16	0-15(15)
	Clasize	Clasize	Number of students in class	198	4.41	1.58	1-7(6)
Time for learning	Ttimew	Timspw[#]	Scheduled time/week	198	2.87	1.38	1-5(4)
	Ttimts	Ttimpw[#]	Science teaching time/week	198	4.40	1.86	1-8(7)
Professional teaching force	Pcaddu	Admindt	Principal administrative duty	198	3.33	1.55	1-7(6)
	Pcsuevt	Supevdt	Supervise or evaluate as principal duty	198	2.05	1.05	1-7(6)
	Proftchingf	Proftchf[#]	Professional teaching force	198	13.97	2.46	7-20(13)
School climate	Enrtot	Schsize[#]	Enrolment of all grades	198	3.04	1.35	1-7(6)
	Citysize	Citysize[#]	Type of community	198	3.12	1.58	1-6(5)
	Studis	Disadva	Percentage of disadvantaged students	198	3.76	0.68	1-4(3)
	Hixpect	Hixpect[#]	High expectation	198	5.67	1.64	2-10(8)
	lowmorals	Lomoral	Severity of low morale	198	4.37	2.16	0-8(8)
	Safeschag	Safschag*	Safety in school	198	2.39	0.54	1.27-3.87(2.6

*Note: * aggregated variable*
[#] *non-significant variables according to the multilevel analysis*
[@] *deleted variable due to low deviance improvement*

TIMSS collected contextual information at four levels, viz., student, class, school and context (or country) level, and the current study examined three levels among them, excluding context level. Although there are three-level questionnaires examined, as TIMSS sampled one class per school, the data from class level and school level were not distinct from each other. If more than one class per school are sampled, one can explore the variance between classes within a school. Therefore, the study built a two-level model representing the student and class/school level, just as other studies had previously addressed using TIMSS data (Bos, 2002; Howie, 2002). Accordingly, the multilevel analyses used a two-level model that consists of student and class/school level.

8.2.2 THE INITIAL MULTILEVEL MODEL

The MLwiN software was used to specify a two-level model. Even though there are three-level questionnaires, since TIMSS 2003 was addressed to one classroom per school, there are no between-class variations within the school observed. Therefore, a two-level model was built, representing the student and class/school level. The model built here is to explain the variation in science scores between students (within schools) and between schools by the explanatory variables.

A two-level model for Korea was proposed in Figure 8.1 (below). The direct relationship between the variables at each level and science achievement was investigated, and it was presumed according to the results summarized previously that seven variables at the student level and eight variables at the classroom/school would have an effect on science achievements of Korean students. The model proposed here can be compared to the final model in Chapter 9.

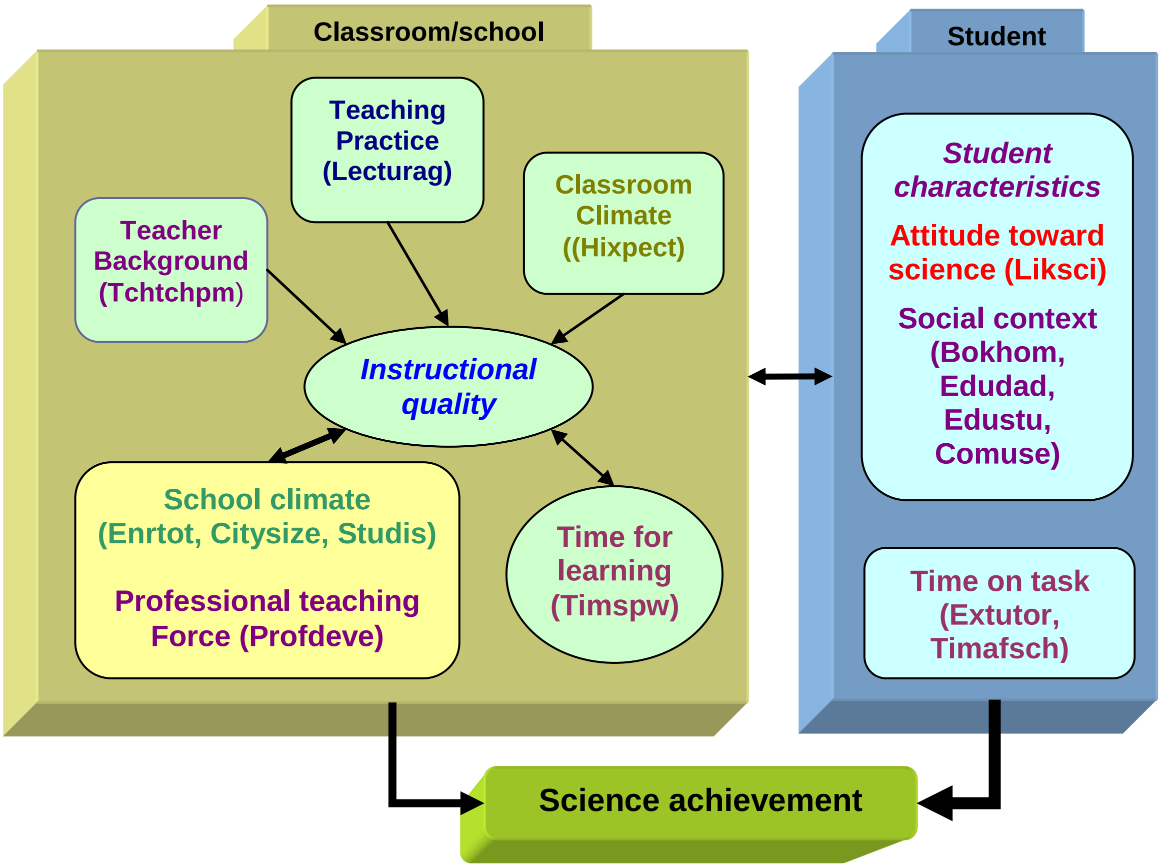

Figure 8.1 **Korean model proposed for multilevel analyses**

The South African two-level model proposed for multilevel analyses is presented in Figure 8.2 (below). The direct relationship between each independent variable and science achievement was examined. It is presupposed based on the results identified previously, that eight variables at the student level and 19 variables at the classroom/school would influence student achievement in science in South Africa. The model proposed for South Africa can be contrasted to the final model shown in Chapter 9.

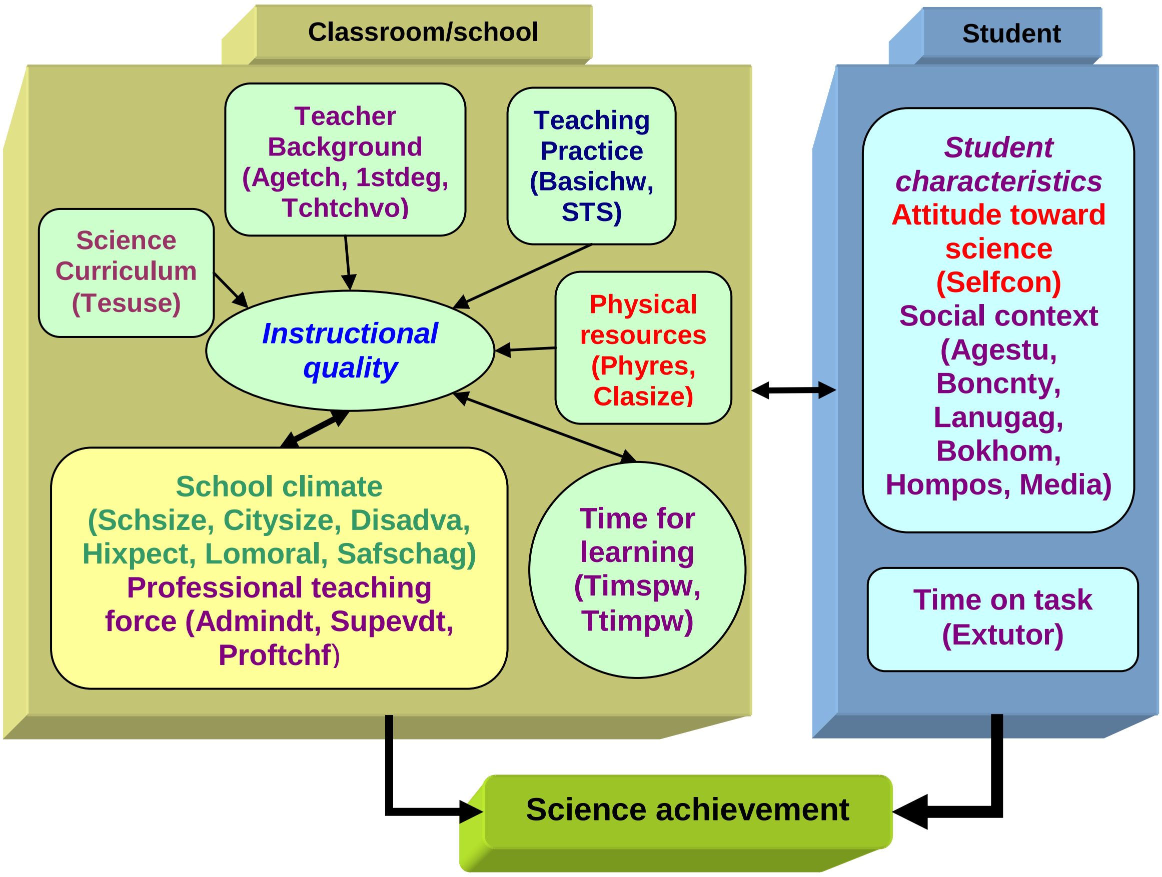

Figure 8.2 **South African model proposed for multilevel analyses**

8.2.3 APPROACH TO MODEL BUILDING

A data set was compiled in preparation for model building which had no missing data prior to testing the model presented above. All the student, teacher, and school level variables were merged into one dataset in the SPSS programme. The identifiers in the multilevel analysis are school and student. The data set was sorted according to these variables. Ultimately, 137 schools and 4,876 students in Korea were included in the analysis. Regarding South Africa, 198 schools and 6,784 students were included in the multilevel analysis (see Tables 8.3 and 8.4, above).

The multilevel analyses were developed from the null model to the final model. As added explanatory variables increase, the estimated number of parameters increases and thus it makes the model complicated. Therefore, starting with the simplest possible model is preferable (Hox, 2002), and it makes it possible to see if a multilevel modelling is appropriate and how many levels should be included. Explanatory variables at the student level and class/school level were added to the model built on a one-by-one basis. In particular, the model built here used fixed regression coefficients along with variance components, since fixed parameters are considered as likely to be estimated with much more precision than random parameters (Hox, 2002).

Once each variable was added, significance testing of the newly produced parameter was carried out by means of a Z-test, and the contribution to the model was examined by identifying any change in the deviance. The difference (chi-square variant) of the deviance from the model under investigation to the null model was computed to find out whether or not there was any improvement in each consecutive model (Hox, 2002).

There were a number of variables retained as significant in the two datasets after the multilevel analysis for the student level and class/school level. However, it is important to note that multilevel modelling can avoid making the built model complicated and the interpretation difficult (Hox, 2002). Rather, researchers can make a clearer and stratified interpretation of phenomenon by means of multilevel modelling. For that reason, interaction effects across levels were examined by more limited models, with only those parameters that have been proven worth examining by previous research, or being of special interest from the perspective of the conceptual framework (Hox, 2002).

8.3 THE RESULTS OF THE MULTILEVEL ANALYSES

There were many models run, however, for the purposes of presentation only the final models are included in this chapter, and all the models run are included in Appendix K and L. First, the null model was presented, along with the deviance (Section 8.3.1). Thereafter, the student model and the student-class/school model followed (Section 8.3.2 and 8.3.3). The proportion of variance explained at each model is described and finally the interaction effects are discussed (Section 8.3.4).

8.3.1 THE NULL MODEL

The null model or intercept-only model contains only the dependent variable (science achievement score) with no explanatory variables, which refer to student or class/school level variables (Hox, 2002). The null model is a base on which consecutive models can be built and evaluated. The null model makes it possible to estimate the total variance in the science score. Accordingly, it can help to estimate how the variation in students' achievement was divided into between-students variance and between-schools variance without any explanatory variables (Howie, 2002).

The null model specified in the first step of running the two-level model is:

$$\text{Achievement}_{ij}=\beta_0+u_{0j}+e_{ij}$$

where achievement$_{ij}$ is the specific score on the science of the i^{th} student of the j^{th} school, written as the sum of:

β_0 : the intercept (the grand mean of the science scores)
u_{0j} : the average score of the j^{th} school
e_{ij} : a residual part, the student error term.

As shown in Table 8.5 (below), the intercept of the null model for Korea is 558 (1.878), which is equivalent to the result of Table 6.1. The variance of the residual part for the student level is 4646 (95.445), and 350 (58.353) for the class/school level. The standard errors are all smaller than the estimated parameters. To evaluate whether or not these parameters are significant, the Wald test, referred to as the Z-test, was employed. Z values can be calculated with the formula 'Z=parameter/SE' and compared to a standard normal distribution. The result was that all parameters were statistically significant at $p<0.001$, which means that effects depending on levels do exist and variables from the two levels should be included.

The results of the null model for Korea reveal the overall variation in science achievement is derived predominantly from between-students variance (93%), while only about 7% of the variation comes from between-schools variance in the Korean data (see Table 8.8). This means that within the country the differences between schools in Korea were quite small. This result is consistent with the previous research undertaken in other developed countries (Kupari, 2006).

Table 8.5 ***The null models***

Effects	**Null model**			
	KOREA		SOUTH AFRICA	
	Coefficient	Standard error	Coefficient	Standard error
Fixed effects				
Intercept	558.307	1.878	245.040	7.223
Random effects				
σ^2_e	4646.078	95.445	7034.088	122.582
σ^2_{u0}	350.446	58.353	10109.060	1037.217
Deviance	55187.250		80118.130	

The intercept of the null model for South Africa is 245 (7.223), which is almost equivalent to the result of Table 6.1. The variance of the residual error term is 7034 (122.582) for the student level and 10109 (1037.217) for the class/school level respectively. The standard errors are smaller than estimated parameters as in Korea. The result of the Z-test indicated that all parameters were statistically significant at $p<0.001$, implying that effects derived from the two levels are worth examining.

The null model for South Africa can also be used to estimate the intra-class correlation, which is referred to as the proportion of the total residual variation that is attributed to differences between schools. As for the explained proportion of the total residual variation, 41% of the variation in science achievement is attributable to student level and 59% is the proportion of the total residual variation derived from between-schools variance (see Table 8.9, below). This is the opposite of what was observed in the Korean data and consistent with previous research (Howie, 2002; Scherman, 2007). Howie (2002) found that 55% of the variance explained was on the school level, and 45% of the variance was on the student level in South Africa using mathematics in TIMSS-R. Scherman (2007) documented 46% of the total variance as attributable to the school level, 5% to the teacher level, and 49% to the student level in the study to ascertain which factors influence the performance of South African learners on the Middle Years Information System assessment.

8.3.2 STUDENT MODEL

Once the null model was explored, the student-level model was built. In this model, students' background variables were added to the model as explanatory variables to estimate how much of the variance the student-level variables explain before considering the class/school-level variables. The student-level model was specified by the following equation:

$$\text{Achievement}_{ij} = \beta_{0j}+\beta_{10}X_{ij}+e_{ij}$$

Where $\beta_{0j} = \beta_0+u_{0j}$ and β_{10} is the intercept for X_{ij} which represents explanatory variables at the student level. The explanatory variables were included consecutively as the model was developed. As each individual variable was added, the contribution of the explanatory variable was assessed in order to ascertain whether the variable improved the model. The equations for the two countries are described in more details in Section 8.3.2.1 for Korea and Section 8.3.2.2 for South Africa.

8.3.2.1 Student-level model for Korea

The student-level model was progressed from the null model by including variables on a one-by-one basis. The student-level model was developed separately for each country. Using variable labels included instead of algebraic symbols, the equation for Korea reads:

$$\text{achKOR}_{ij}=\beta_{0j}+\beta_1\text{liksci}_{ij}+\beta_2\text{bokhom}_{ij}+\beta_3\text{edustu}_{ij}+\beta_4\text{timafsch}_{ij}+\beta_5\text{edudad}_{ij}$$
$$+\beta_6\text{extutor}_{ij}+e_{ij}$$

The variables above were inserted one-by-one into the model to estimate the effect of each variable according to the step-by-step procedure described in Chapter 5. Six out of seven variables selected for the multilevel analysis in Korea were statistically significant, as shown in Table 8.6 (below). ‘Computer use’ (comuse) was not significant at the student level in Korea. In particular, ‘attitudes towards science’ (liksci) proved to be clearly the strongest predictor for the between-students variance and increased the percentage of explained variance by 16% points. With a closer look at Table 8.3 and Table 8.6, a student who has a highly positive interest in science may score the most, with 101 (4.821*21=101.241) points more than a student who has an extremely negative attitude toward science. In addition, a student who takes extra tutoring and spends more time studying after school, will score up to 56 points more than a student who does nothing related to science after school (5.715*8 + 3.360*3=55.8). Likewise, a student who has more books in the home and a more educated father will score 71 points more than a student who does not (11.901*4+3.352*7=71.068). The more a student expects to move into higher-education, the better s/he may score, by up to 76 points (18.901*4=75.604). To sum up, variables that can be manipulated or developed by education practice, such as ‘attitudes towards science’ and ‘time on task’, resulted in a significant effect on science achievement, which means it is worth making an effort to improve them.

Table 8.6 ***Multilevel analyses of the Korean dada***

Model	Null model	Student model	Class/school model
Fixed effects			
Student level			
	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	558.307(1.878)	329.016(5.459)	319.418(9.634)
Attitude toward science			
Liksci		4.821**(0.212)	4.759**(0.211)
Social context			
Bokhom		11.901**(0.701)	11.779**(0.698)
Edustu		18.901**(1.199)	18.993**(1.195)
Time on task			
Timafsch		5.715**(0.659)	5.683**(0.656)
Social context			
Edudad		3.352**(0.551)	2.878**(0.554)
Time on task			
Extutor		3.360**(0.639)	3.309**(0.636)
Class/school level			
School climate			
Disadva			-5.417**(1.181)
Schsize			1.656*(0.776)
hixpect			0.747*(0.371)
Professional teaching force			
Prodeve			1.305*(0.614)
Random effects			
σ^2_e	4646.078(95.445)	3225.629(66.264)	3223.994(66.223)
σ^2_{u0}	350.446(58.353)	91.298(22.076)	43.997(16.357)
Deviance	55187.250	53325.210$^{\#}$	53281.750$^{\#}$

Note: N=4876 learners in 137 schools
*** t-value > 2.58 a confidence interval of 99%*
** t-value > 1.96 a confidence interval of 95%*
$^{\#}$ Deviance from null model to present model is significant at 0.01

The variance in science achievement at student level, (Table 8.6, above) describes the changes occurring in that variance when different background variables are controlled. As can be seen in Table 8.6, the difference between the deviances of the student model and the null model are highly significant. This deviation is a measure of the likelihood of the appropriateness of the student model as compared to the null model. It is considered that the student model (53325) improved significantly when compared to the null model (55187).

8.3.2.2 Student-level model for South Africa

Based on the null model, a student-level model for South Africa was developed similar to the one for Korea. The equation for South Africa using variable labels included is:

$$\text{achRSA}_{ij}=\beta_{0j}+\beta_1\text{selfcon}_{ij}+\beta_2\text{boncnty}_{ij}+\beta_3\text{agestu}_{ij}+\beta_4\text{tutorsci}_{ij}+\beta_5\text{media}_{ij}+\beta_6\text{languag}_{ij}+\beta_7\text{hompos}_{ij}+e_{ij}$$

With regard to South Africa, seven out of eight student-level explanatory variables identified in Table 8.4 were statistically significant as shown in Table 8.7 (below), and one variable, ‘books at home (bokhom)’, was excluded because this variable did not improve the deviance, indicating the goodness of fit of the model. Therefore, no difference of deviances between the models with and without ‘books at home’ means the variable does not improve the goodness of fit of the model. As in Korea, ‘attitudes towards science’ (selfcon) proved to be the strongest predictor when using the South African data for the between-students variance and increased the percentage of explained variance by 8% points (see Appendix L). A student who has more self-confidence in science may score 73 points higher than a student who has an extremely lower level of self-confidence in science (8.162*9=73.458), and given that the intercept of the null model was 245 points, self-confidence in science can be thought of as having a great effect on science achievement. It is also revealed that social context concerning ethnicity, such as ‘born-in country’ (boncnty) and language at home (languag), have an influence on science achievement. A student who was born outside the country, which might mean an immigrant, scored less by 43 points than natives (43.060*1=43.060), and students who speak the language used in the test at home more often may score up to 40 points more than those who do not (13.319*3=39.957). Variables such as ‘watch TV or video after school’ (media) and ‘home possession’ (hompos) also turned out significant. A student who watches TV or video after school scored up to 25 points more than others (6.360*4=25.44), and the more students have possession in their home the better they scored, up to 31 points (2.805*11=30.855). The oldest students scored 43 points less than the youngest students in classrooms (10.809*4=43.236). Students who took extra tutoring in science, besides regular classes, scored 32 points less than those who did not (10.638*3=31.914).

The results do not differ substantially when compared to those using the Korean data in terms of the factors such as ‘attitudes towards science’, ‘social context’, and ‘time on task’. However, a closer look at the specific variables under each factor revealed a slightly different picture. For example, ‘attitudes towards science’ in Korea cover ‘liking science’ and ‘self-confidence in science’ (see Section 7.2.1.1). In contrast, ‘attitudes towards science’ in South Africa only means ‘self-confidence in science’ (see Section 7.2.1.2), which has a narrower coverage than in Korea. In addition, ‘time on task’ influences science achievement in reverse in the two countries. It can be said from a policymaker’s point of view that the two countries have in common variables that can be manipulated or developed by interventions. For example, the results show that ‘attitudes towards science’ and ‘time on task’ have more influence on science achievement than other variables such as ‘social context’. Research has documented that teachers or schools can improve those factors by some intervention, and thus student achievement (Dechsri et al, 1997; Freedman, 1997; Odom et al., 2007). Nonetheless, the results are still subject to change, depending on the addition of other variables.

Table 8.7 ***Multilevel analyses of the South African data***

Model	Null model	Student model	Class/school-model
Fixed effects			
Student level			
	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	245.040(7.223)	92.750(7.032)	135.674(29.915)
Attitude toward science			
Selfcon		8.162**(0.412)	8.102**(0.411)
Social context			
Boncnty		43.060**(2.204)	41.934**(2.183)
Agestu		10.809**(0.739)	10.868**(0.733)
Time on task			
Extutor		-10.638**(0.967)	-9.983**(0.963)
Social context			
Media		6.360**(0.701)	6.453**(0.699)
Languag		13.319**(1.351)	13.029**(1.323)
Hompos		2.805**(0.413)	2.809**(0.408)
Class/School level			
School climate			
Safschag			49.986**(5.295)
Disadva			-27.896**(4.566)
Physical resource			
Phyres			-3.050**(0.703)
Teacher background			
1stdeg			16.977**(7.322)
Professional teaching force			
Admindt			3.809*(1.813)
Teacher background			
Agetch			10.891**(3.171)
Science curriculum			
Textuse			-28.560**(10.153)
Resource			
Clasize			-2.878*(1.598)
Teaching practice			
STS			-2.197*(1.109)
Professional teaching force			
Supevdt			-6.592**(2.718)
School climate			
Lomoral			-2.165*(1.217)
Random effects			
σ^2_e	7034.088(122.582)	5609.017(97.749)	5608.399(97.738)
σ^2_{u0}	10109.060(1037.217)	4633.674(482.463)	1089.370(126.504)
Deviance	80118.130	78475.770#	78210.480#

Note: N=6784 learners in 198 schools, # Deviance from null model to present model is significant at 0.01
** t-value > 1.96 a confidence interval of 95%, ** t-value > 2.58 a confidence interval of 99%*

In terms of social context, educational factors such as ‘books at home’, ‘parent education level’, and ‘students’ expectation of higher education’ were significant in Korea. In contrast, ethnical factors such as ‘born-in country’ and ‘students’ language at home’ were significant effectors in South Africa.

8.3.3 CLASS/SCHOOL-LEVEL MODEL

Once the student model was confirmed, the class/school level variables were added to the student model step-by-step, resulting in the class/school model. The model can be written as:

$$\text{Achievement}_{ij} = \beta_{0j}+\beta_{10}X_{ij}+ \beta_{01}Z_j+e_{ij}$$

where β_{01} is the intercept parameter for Z_j it represents explanatory variables at the class-school level. The equations of the class/school model for the two countries are presented in more details in Section 8.3.3.1 for Korea and Section 8.3.3.2 for South Africa.

8.3.3.1 Class/school-level model for Korea

Class/school-level models were built in accordance with the procedure outlined in Section 5.10.2. Using variable labels instead of algebraic symbols, the equation for Korea reads:

$$\text{achKOR}_{ij}=\beta_{0j}+\beta_1\text{liksci}_{ij}+\beta_2\text{bokhom}_{ij}+\beta_3\text{edustu}_{ij}+\beta_4\text{timafsch}_{ij}+\beta_5\text{edudad}_{ij}$$
$$+\beta_6\text{extutor}_{ij}+\beta_7\text{disadva}_j+\beta_8\text{schsize}_j+\beta_9\text{hixpect}_j+\beta_{10}\text{prodeve}_j+e_{ij}$$

The equations above represented only the variables that were statistically significant. Whereas most of variables added at the student level have a significant effect on science achievement, with only a single variable being not significant in the two countries respectively, there are many class/school-level variables which turned out as non-significant effects on science achievement when added to the second model. Non-significant variables include ‘teacher interaction by material or pedagogy’ (tchtchpm), ‘lecture-centred teaching’ (lecturag), ‘time scheduled per week’ (timspw), and ‘type of community’ (citysize). Accordingly, of eight class/school-level variables in the Korea data, only four variables were statistically significant.

Taking a closer look at a specific variable, ‘percentage of disadvantaged students’ (disadva) emerges as the strongest predictor at the class/school level. The more schools have students who come from disadvantaged homes, the worse the students fared, by up to 16 points (5.417*3=16.251). The larger schools performed better by 10 points (1.656*6=9.936), and a stronger educational ethos such as ‘high expectation’ (hixpect) resulted in a higher performance by up to 12 points (0.747*16=11.952). The more teachers are involved in professional development, the better their students fared, by up to 12 points (1.305*9=11.745).

8.3.3.2 Class/school-level model for South Africa

As in Korea, the equation for South Africa can be represented using variable labels instead of algebraic symbols, as:

$$\text{achRSA}_{ij}= \beta_{0j}+\beta_1\text{selfcon}_{ij}+\beta_2\text{boncnty}_{ij}+\beta_3\text{agestu}_{ij}+\beta_4\text{exturtor}_{ij}+\beta_5\text{media}_{ij} +\beta_6\text{languag}_{ij}+\beta_7\text{hompos}_{ij}+\beta_8\text{safschag}_j+\beta_9\text{disadva}_j+\beta_{10}\text{phyres}_j+\beta_{11}\text{1stdeg}_j +\beta_{12}\text{admindt}_j+\beta_{13}\text{agetch}_j+\beta_{14}\text{textuse}_j+\beta_{15}\text{clasize}_j+\beta_{16}\text{STS}_j +\beta_{17}\text{supevdt}_j +\beta_{18}\text{lomoral}_j +e_{ij}$$

Unlike the Korean results, the South African results have more variables that are significant after non-significant variables were removed. Among 19 class/school variables tested, 11 variables remained statistically significant. It also happened that when a variable was first added to the equation, it had a significant effect, but when the next variable was added the variable was no longer significant, as was the case with variables such as ‘type of community’ (citysize), enrolment of all grades’ (schsize), and ‘interaction by visit or observation’ (tchtchvo). There might be some effects that cancel each other out, or are related to each other (Howie, 2002).

An aggregated variable, ‘safety in school’ reported by students (safschag) was the strongest predictor at the class/school level. A student who thinks that s/he attends a school in which the less bullying happens may perform better by 130 points (49.986*2.6=129.9636). Given that the initial intercept was 245 points, this is a substantial result. Other variables concerning school climate, such as ‘percentage of disadvantaged students’ (disadva) and ‘severity of low morale’ (lomoral) were also significant.

With regard to resource variables, ‘physical resource for science’ (phyres) and ‘number of students in class’ (clasize) turned out to have significant effects. A science curriculum variable, ‘textbook use’ (textuse), was statistically significant. It is however surprising that textbook use in class negatively influences student achievement by up to 29 points (-28.560*1=-28.560). A possible explanation might be that using a textbook means reading the text only, without any explanation. Judging from the researcher’s experience in secondary schools it is not enough to read the text when teaching scientific knowledge and skills to students. It should be translated corresponding to students’ cognitive development stage. From the descriptive statistics, it was previously found that South African teachers tend to use textbooks as a supplementary resource. As mentioned in the preliminary analysis, there is a need for further research to ascertain how teachers are actually using science textbooks in their classes.

Among the teacher background variables, there were two variables that were statistically significant, namely ‘completion of the first degree’ (1stdeg) and ‘teacher age’ (agetch). Students whose teachers were older or more experienced, and had completed the first degree, performed better than the others, with up to 61 points (43.564*4+16.977*1=60.541).

Professional teaching force, which was defined as educational leadership (see Section 3.3.5.2), and in particular educational leadership by principals, was evidenced as an effective factor in research. There were two variables that explained student achievement with statistical significance, namely ‘administrative duty’ (admindt) and ‘supervising or evaluating teachers’ (supevdt). It is predicted that the more devoted the principal is to administrative duty and the less involved in supervising or evaluating teachers, the better the students performed in science, by up to 62 points (3.809*6+6.592*6=62.406).

South Africa has more variables that are significant at the class/school level than Korea. In particular, resource- and teacher background-related factors such as ‘physical resource for science lesson’ (phyres) or ‘completion of first degree’ (1stdeg) influenced student science achievement in South Africa. Of interest is that only a single variable, ‘percentage of disadvantaged students’ (disadva), is significant in both countries at the classroom/school model. For the most part, variables that accounted for student science achievement in each country are quite different as compared in Table 8.3 and Table 8.4. This might imply that factors influencing student achievement are common across the countries; however, the educational condition of each country only exposes which one is more urgent or significant at that present time.

8.3.4 PROPORTION OF VARIANCE EXPLAINED BY THE CONSECUTIVE MODELS

By examining the change occurring in the estimates of variance after adding each set of variables, the researcher analyzed the effects of different level variables on student science achievement. The proportion of the total residual variation that is due to differences between schools, referred to as ‘intra-class correlation’, can be calculated by the formula $R^2 = \sigma^2_e/(\sigma^2_e+\sigma^2_{u0})$. Thereafter, the total variance explained by the consecutive models can be calculated by the formula $R^2_e = (\sigma^2_{e0}-\sigma^2_{e1})/\sigma^2_{e0}$ and $R^2_u = (\sigma^2_{u0}-\sigma^2_{u1})/\sigma^2_{u0}$ (Hox, 2002). After calculating the total variance, Akaike Information Criterion (AIC) was also calculated. The AIC is a fit statistic based on the deviance, and can be calculated by adding the deviance and twice the number of parameters. The lower the value of the AIC, the better the model (Scherman, 2007). The results of the calculation are described in Section 8.3.4.1 for Korea and Section 8.3.4.2 for South Africa.

8.3.4.1 Proportion of variance explained for Korea

A closer look at the Korean results shown in Table 8.8 (below) reveals that most of the variance in the null model occurred at the student level (93%), while relatively small percentages of the variance (7%) were attributable to the classroom/school level. From a point of view that the degree of variability within a classroom/school or between classrooms/schools indicates the homogeneity of the classroom or school environments where students learn (O'Dwyer, 2005), the large amount of variance explained at the student level indicates that students attending one school are really heterogeneous across the country. Likewise, the small amount of variance explained at the school level means schools in Korea do not vary much across the country. This finding is in accordance with several earlier studies in other countries using mathematics achievement (Reezigt et al., 1999; O'Dwyer, 2005; Kupari, 2006).

Table 8.8 ***Explained proportion of variance by consecutive models for Korea***

	Null model	Student model	Class/school model
Student–level Variance	0.930(93%)	0.306(30.6%)	0.306(30.6%)
Class/school-level variance	0.07(7%)	0.739(73.9%)	0.874(87.4%)
AIC	55193.25	53343.21	53307.75

The student-model explains 31% of the total variance at the student level and 74% of the variance at the class/school level in the null model (Table 8.8, above). Consecutively adding the class/school variables to the student model to some extent increased (from 74% to 87%) the proportion explained for between-schools variance, but it made no difference in view of the between-students variance (within-schools).

In the student-class/school model, the class/school-level variance is estimated at 87%, whereas 31% is estimated on the student-level. Thus, it seems clear that there are additional factors that would need to be explored at each level to account for the unexplained variance. One of the possible factors might be ‘student aptitude’, which is evidenced as more likely to influence student achievement as reviewed in Chapter 3 (Fraser, 1989; Lindemann-Matthies & Kamer, 2006), and TIMSS did not collect any data on aptitudes towards science, such as prior achievement or opportunities used at the student level.

The largest contributor in terms of explaining the variance within school is ‘attitudes towards science’ (liksci) (16%) (see Appendix K). ‘Books at home’ (bokhom) (8%) and ‘school expected by students’ (edustu) (5%), all of which are also good predictors at the student level. The greatest contributor in terms of explaining the variance between schools is ‘books at home’ (bokhom) (29%). ‘Percentage of disadvantaged students’ (disadva) (10%) and ‘father education level of father’ (edudad) (9%) increased the percentage of explained variance. The rest of the variables brought only a slight increase to the proportion explained both for the within and between school variance. On the whole, the added variables increased the percentage of explained variance on the class/school-level model rather than on the student-level model.

8.3.4.2 Proportion of variance explained for South Africa

The South African results revealed quite a different picture from the Korean results. As opposed to the result that Korean student achievement in science is explained mainly by the student-level variables, the class/school level variables accounted to a greater extent for the South African science achievement. More than half of the total variance in science achievement, for the null model, is on the class/school level (59%) and the rest (41%) can be explained at the student-level implying that the South African teachers and schools are heterogeneous across the country to a greater extent than in other countries, including Korea.

Table 8.9 ***Explained proportion of variance by consecutive models for South Africa***

	Null model	Student model	Class/school model
Student level variance	0.410(41.0%)	0.203(20.3%)	0.203(20.3%)
Class/school level variance	0.590(59.0%)	0.542(54.2%)	0.892(89.2%)
AIC	80124.13	78495.77	78252.48

The student-level model explains 54% of the between-school variance, whilst only 20% of the within-school variance is explained. In the class/school model, a higher proportion of the variance is explained between schools (89%), while the variance explained within-schools is not different, as expected. As was the case in Korea, a higher proportion of variance explained between schools than within schools was explained in the final model, implying additional factors to be explored at each level to account for the unexplained variance.

The largest contributory predictor at the class/school level is ‘safety in school’ perceived by students (safschag) (24% on the class/school level) and to a lesser extent ‘attitudes towards science’ (selfcon) (14%) at the student-level model (see Appendix L). ‘Language at home’ (language) and ‘physical resource for science lesson’ (phyres) increased the percentage of explained variance by 10% and 9% respectively on the class/school-level model. The remaining variables brought only a slight increase in the proportion explained both for the within and between school variance, although there were many variables added at the class/school level. As was the case in Korea, and expected from Table 8.9 (above), as variables are added to it was more likely to increase the percentage of explained variance on the class/school-level model than on the student-level model.

Once all the explanatory variables were inserted to the model, most of the class/school level variance in science achievement may be explained in the model. Whereas 87% and 89% of the total variance explained between schools in the null model were estimated at the final model for Korea and South Africa respectively, it did not hold for the student-level variance as shown in Tables 8.8 and 8.9. Only 31% and 20% of the total variance explained in the null model were explained by the variables added in Korea and South African respectively. This may imply that other variables not included but significant do exist in particular at the student level. It was documented that students' aptitude, such as cognitive ability, explained a great deal of the variance at the student level (Van den Broek & Van Damme, 2001). As put forward, TIMSS did not address a question related to aptitude due to issues such as time and cost limit. In addition, prior achievement, which is also referred to as student aptitude, cannot be collected as TIMSS is not a value-added and longitudinal study but a cross-sectional study addressed. There is, however, need to develop an item or a question to account for the unexplained variance at the student level. On the other hand, the result that most of the variance between schools is explained by variables added here means the gaps between schools in terms of student science achievement can be attributed to these very variables.

8.3.5 INTERACTION EFFECTS

As a final step of the multilevel analysis, the cross-level interaction effects were investigated. A number of possible interactions between a variable from the student level and a variable from the class/school level were examined comprehensively. In particular, 'attitudes towards science' at the student level was the prior interest of the researcher since it was considered as an easy-to-manipulate variable at the class/school level by science teachers. There were some interaction effects, which were statistically significant in the Korean data but in terms of the variance explained, they did not improve substantially the fit of the model to the data at all. Regarding South Africa, there was some interaction effects between such variables as 'attitudes towards science', 'student age', 'extra tutoring', and 'home possession'. However, no interaction effect could better fit the previous model, as was the case in Korea. Consequently, no effects worthy of inclusion emerged in the investigation.

8.4 CONCLUSION

The selection of the variables was made prior to multilevel analysis. The selection was based on the results of the preliminary analyses outlined in advance. The research framework drawn in Chapter 4 also contributed to the choice of the more appropriate factors. With the selected variables, multilevel analysis was carried out separately for Korea and South Africa. Although the difference between Korea and South Africa was expected, the results of multilevel analysis clarified this aspect. Ultimately, the exploration in this chapter draws the answers to the second main question, '***To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?***'. The question constitutes four specific questions regarding generic and specific factors, as well as the degree of variance explained in terms of science achievement in Korea and South Africa.

First, at the student-level model, it seemed that the two countries had factors in common in terms of 'attitudes towards science', 'social context', and 'time on task'. 'Attitudes towards science' emerged as the most significant factors in both countries. The time-on-task factors, such as extra tutoring, were also significant in both countries, although they worked in reverse. However, social context factors gave a slightly different picture. South Africa has more ethnic factors such as 'born-in country' and 'language at home', whereas Korea has more educational factors such as father education (edudad), 'school level expected by student' (edustu), and 'books at home' (bokhom).

Nonetheless, it is worth explaining that the two countries have variables in common that can be addressed by interventions such as 'attitudes towards science' and 'time on task', which tend to have more influence on science achievement than other variables such as 'social context' that cannot be manipulated.

Next, at the class/school-level model, the differences between the two countries were more distinguishable than at the student-level model. The result shows South Africa has 11 significant variables at the class/school level, as opposed to four significant variables in Korea. As a common point prior to the difference, the percentage of students who come from disadvantaged homes influenced student achievement in science in both countries.

Another difference of interest is that aspects of teacher background, such as 'teacher age' and 'completion of first degree' were important in South Africa. Furthermore, variables pertaining to resources such as 'physical resource' and 'class size' were significant as well. The largest contributor was 'safety in school' perceived by students. As for Korea, besides 'percentage of disadvantaged students', there are 'high expectation', 'professional development', and 'enrolment of all grades' which were significant and accounted for the variance between schools.

The greatest difference is the portion of variance explained. Whilst 93% of the variance explained occurred at the student-level model, only 7% of the variance is attributed to the class/school-level variables in Korea. Regarding South Africa, 41% of the variance explained is attributed to the student-level variables and 51% to the class/school-level variables, which is a much higher proportion compared to Korea, implying that South African schools are more likely to influence student achievement in science.

As expected from the beginning, different variables which influence science performance operate in Korean and South African schools, although some common variables function. It might be suggested that intervention or manipulation by decision-makers should take these differences into account in order to improve science achievement across countries. This is assuming that the educational condition of each country only exposes the variable which is more urgent or significant at that time.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

Although TIMSS summarises mean achievement and provides a global view of how countries compare to each other, such differences do not take into account the varying education systems and the factors which possibly could have contributed to variations in performance. Countries such as Korea and South Africa, examined in this study, differ in many ways with respect to their social and educational, cultural, historical, and demographic contexts. These differences may affect the observed differences in science achievement amongst students in each of the contexts. Such achievements tend to be considered as a reflection of the quality of education and thus outcomes need to be examined in the learning context of individual countries (Association for the Development of Education in Africa, 2003).

In order to better understand the different learning environments in which students learn in these countries, the current research used multilevel modelling techniques to deconstruct the total variance in Grade 8 TIMSS 2003 science achievement in Korea and South Africa into within- and between-class/school level. As a preliminary stage of variable selection for inclusion in the model, this research included exploring descriptive statistics, factor, reliability, and correlation analysis to better identify the factors associated with higher achievement. The selection of variables included in the models was guided both by the conceptual framework and extensive preliminary analyses. Subsequently, the research identified predictors of achievement at the individual and class/school levels that explain some of the variance within and between class/schools in both countries.

In this final chapter, the summary of the research into answering the research questions is given (Section 9.2), followed by reflections and discussions on the conceptual framework developed, and the methodology used (Section 9.3). It also outlines how this research may contribute to the body of knowledge in the domain of education. Thereafter, recommendations for further research are presented for Korean and South African science education, TIMSS, and SER (Section 9.4). Finally, conclusions are drawn (Section 9.5).

9.2 SUMMARY AND THE RESEARCH QUESTIONS

The purpose of this research was to explore the difference between Korean and South African student achievement in science from the perspective of educational effectiveness. As a preliminary stage, the educational contexts of the two countries were explored in Chapter 1. Korean education has a long tradition, based mainly on Confucianism, and is highly competitive as parents and students have a strong zeal for higher education that is believed to create opportunities for socially-upward mobility. As a result, most of the students tend to take extra tutoring after school. In addition, education is highly centralised in terms of curriculum and management (Lee, 2002).

On the other hand, South African education featured segregation according to different racial groups for a long period of colonization with the result of a backlog in education delivery and unequal distribution of resources. Therefore, the black majority was deprived of qualified teachers, physical resources, and teaching aids (Fiske & Ladd, 2004). In recent years the democratic government has tried to redress such inequity and promote racial equity through various educational reforms.

The two countries are found at opposite ends of the achievement scale in TIMSS, which was conducted by the IEA, a large scale international comparative study of student achievement in mathematics and science. The substantial gap between Korea and South Africa in science achievement led to the main research questions as follows: *To what extent does TIMSS 2003 reflect factors related to effective science education? To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?*

To provide answers to these questions, a framework for effective science performance was built by consulting school effectiveness research (SER) and reviewing extensive previous research concerning science performance, as described in Chapter 3 (Scheerens, 1990; Stringfield & Slavin, 1992; Creemers, 1994; Teddlie & Reynolds, 2000; Scheerens, 2001; Howie, 2002; Kyriakides, 2005). SER identified many factors to explain student outcomes in schools at various levels. At student level, ‘time on task’, ‘opportunity to learn’, and ‘student social contexts’ including SES, ethnicity, language, and gender were documented in the literature (Reynolds & Walberg, 1991; 1992; Howie, 2002; Papanastasiou, 2002; Papanastasiou & Zembylas, 2004; Von Secker, 2004; Murphy et al., 2006; Shen & Tam, 2008). ‘Instructional quality’ factors including ‘science curriculum’, ‘teacher background’, ‘teaching practice’, ‘resource’, and ‘classroom climate’, as well as time and opportunity to learn, were identified at the classroom level (Fraser, 1989; Wise, 1996; Scheerens & Bosker, 1997; Kahle et al., 2000; Mayer et al., 2000). Many factors related to staff, management, and resources were identified at the school level, specifically ‘principal leadership’, ‘community size’, and ‘school climate’ (Hanushek et al., 1998; Mayer et al., 2000; Supovitz & Turner, 2000; Valverde & Schmidt, 2000; Tate, 2001; Howie et al., 2008). The literature review was extended into science performance-related research to formulate a conceptual framework, particularly for science achievement. Factors derived from the literature review were incorporated into the conceptual framework portrayed in Chapter 4. The conceptual framework drew mainly on the multilevel and integrated school effectiveness model developed by Creemers (1994), factors offered by Scheerens' (1990) and interactions across factors proposed by Shavelson et al. (1989).

The research used the TIMSS 2003 survey data to compare Korea and South Africa in terms of science achievement at Grade 8. For TIMSS 2003, the sample for Korea consisted of 151 schools with 16 explicit strata by province and 83 implicit strata by urbanization and gender, resulting in 5,300 learners participating in the study (Martin, Mullis & Chrostowski, 2004). For South Africa, 265 schools were sampled with 9 explicit strata by province and 19 implicit strata by language, resulting in approximately 9,000 learners being tested across the provinces. Korea tested from 14 to 19 April 2003 (Park et al., 2003) and South Africa tested from 21 October to 1 November 2002 (Reddy, 2006). Instruments addressed in TIMSS 2003 consisted of questionnaires as well as science achievement test items, which were designed to assess science knowledge and skills based on school curricula. The questionnaires were designed to gather information about five broad areas, viz., curriculum, school, teachers and their preparation, classroom activities and characteristics, and students at various levels of the educational system (Mullis et al, 2003), with the study analysing in particular student, science teacher, and principal questionnaires.

Thereafter, appropriate statistical analyses were identified and used in order to address the research questions. It included factor, reliability, and correlation analysis as a preliminary analysis. Finally, this research used multilevel modelling analyses to identify predictors of achievement at the individual and school levels that explain some of the variance within and between classrooms /schools. Details of the methodology were outlined in Chapter 5. Exploratory analysis of the TIMSS data sets from Korea and South Africa were presented by examining the contextual information data in Chapter 6. Background information based on descriptive statistics was elucidated at various levels, namely those of student, classroom/teacher, and school/principal. The results of factor, reliability, and correlation analyses were discussed in Chapters 7 and 8. Finally, answers to the research questions are given in Chapter 9.

The factor analysis of the Korean data identified ten factors at the student level, 22 factors at the classroom level, and 11 factors at the school level. Factor analysis of the South African data also found ten factors at the student level, 22 factors at the classroom level, and 11 factors at the school level. Thereafter, reliability coefficients were calculated to construct internally consistent scales. The results revealed that most of the items examined had internal consistency, and factors that had below criterion, alpha=0.5, are listed as ‘home possession’, ‘attitudes toward subject’ by teachers (knowledge practice), ‘parent involvement’ in Korea, and ‘use of homework’ (extensive) in South Africa. Finally, correlations between the scales or factors and student achievement were examined comprehensively through the questionnaires, including the factors or scales identified above. Correlation analyses of the Korean data identified 13 significant scales or single-item factors at the student level, four factors at the classroom level, and ten factors at the school level. At the other end of the scale, correlation analyses on the South African data identified ten significant scales or single-item factors at the student level, 23 factors at the classroom level, and 17 factors at the school level at the 0.01 or 0.05 significance level. Taking the above analyses into account, answers to the research questions are presented as follows:

Question 1: To what extent does TIMSS 2003 reflect factors related to effective science education?

The first question was translated into three sub-questions, to be answered according to the results of the analyses above. Each sub-question is presented and answered separately in the light of the findings:

1. Which factors at the student level influence science achievement?

Based on the literature review, the conceptual framework and the preliminary analyses, there are ten factors in Korea and nine factors[14] in South Africa identified at the student level that had a significant correlation with student achievement as seen in Table 9.1 (below).

Table 9.1 ***Factors significant at the student level***

Levels	Effective factors		Korea	South Africa
Student	Time on task		Study after school Play after school(-) Extra tutoring	Extra tutoring(-)
	Opportunities used			
	Student characteristics	Aptitudes towards science		
		Attitudes towards science	Liking science Valuing science	Self-confidence in science
		Social context	Books at home Father education Mother education Student education Computer use	Student age(-) Language at home Books at home Home possession People at home(-) Born-in country Media(watch TV)

Note: (-) Negative relationships with science achievement

Time on task, viz., ‘play after school’, ‘study after school’, and ‘extra tutoring’ showed significant relationships with science achievement. ‘Extra tutoring’ was considered to increase time on task as well as content exposure in terms of opportunity to learn (Wang, 1998b). It is evident that the more time students spend on studying and the less on playing, the better they perform, as proposed in teaching and learning theory discussed above (Carroll, 1963; Bloom, 1974). However, ‘extra tutoring’, unlike Korean results, had a negative relationship in South Africa. This can be understood in terms of extra tutoring given to students who were lagging behind by school teachers in order to compensate for their deficiencies in knowledge in South Africa. It should be noted that there are no significant factors related to homework that is considered to increase time on task.

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[14] One factor in South Africa was aggregated and moved to the school level (safe school) as shown in Table 9.3.

Other significant factors are students' attitudes towards science, such as 'liking science', valuing science', and 'self-confidence'. Students who have more positive attitudes performed better within the country, as was the case with many previous studies (Kahle et al., 2000; Shen & Pedulla, 2000; Papanastasiou & Zembylas, 2004; Chang & Cheng, 2008; Howie et al., 2008; Shen & Tam, 2008). This will be discussed further in the second question as a factor generic to Korea and South Africa.

Educational resources referred to as 'books at home', 'father education', and 'mother education' are important and these findings are consistent with previous research (Goldhaber & Brewer, 2000; Von Secker, 2004; Marks, Cresswell & Ainley, 2006). The results also show a significant relationship between Korean students' expectation to progress to higher education and their achievement, which might reflect Korean educational zeal prevailing across the country.

Related to resources, 'computer use' in Korea and 'media' in South Africa showed positive relationships with science achievement. 'Computer use' was reported to have a negative relationship with mathematics achievement in Korea in TIMSS (Park & Park, 2006), but in science teaching practice, instructional technology strategies using computers proved effective (Chang, 2003) as discussed in Chapter 3. Therefore, the results for resources might be explained in terms of teaching practice as well. Regarding 'media', according to Fraser (1989), the more time students spend on leisure such as watching television the less well they performed, as opposed to South Africa which showed a positive relationship with science achievement. This will be discussed further in the second question.

Specifically in South Africa, ethnicity-related factors such as language or born-in country and SES-related factors such as 'student age', 'home possession', and 'people at home' are significant at the student level. Students from disadvantaged homes tend to have large families and to stay at home to take care of ailing parents or their younger siblings in addition to undertaking chores.

Those obstacles keep them from consistently attending school and progressing through grades (Fiske & Ladd, 2004). As a result, older students performed less well than younger students in South Africa. These issues will be discussed further in the second question.

2. Which factors at the classroom level influence science achievement?

The current study focused in particular on classroom as teaching and learning actually take place in the classroom. The conceptual framework also stressed classroom level, specifying instructional quality in various aspects such as science curriculum, teacher background, teaching practice, classroom climate, and physical resources. There are four factors identified at the classroom level in Korea (Table 9.2, below) and three additional factors are presented in teaching practice. There are as many as 23 factors identified in South Africa, where, unlike the Korean results, teacher qualification-related factors such as ‘formal education’, ‘completion of first degree’, and ‘licence type’ are important. In addition, resource-related factors are significant in South Africa. These two issues will be discussed further in the second question.

With respect to teacher background, colleague interaction (infor-interaction) showed a significant relationship with science achievement in Korea. The more often science teachers interact with each other by discussing or preparing materials the better their students score. This finding is consistent with literature indicating that professional development that is school-based, collaborative, and focused on students’ learning is effective (Ruby, 2006). On the other hand, in South Africa, the more teachers interact with colleagues by observing lessons or visiting classrooms the worse their students fare. A possible explanation for this may indicate that observation or visiting by a colleague is currently used to evaluate teachers in South Africa and is seen as threatening rather than as improving pedagogy.

Table 9.2 ***Factors significant at the classroom level***

Levels	Effective factors		Korea	South Africa
Classroom	Instructional quality	Science curriculum		Textbook use(-)
		Teacher background	Inform-interaction	Teacher age Teaching experience Formal education Completion of 1st degree Licence type Preparation to teach physics & chemistry Visit-interaction(-)
		Teaching practice	Practical learning(s) STS learning(s) Lecture learning(s)	STS work(-) Practical work(-)
		Classroom climate	High expectation Class size	High expectation(t)
		Physical resources		Class size(-) Physical resource(-) Computer resource(-) Student SES(-) Computer availability
	Time for learning		Time scheduled per week	Time scheduled per week Inquiry homework(-) Knowledge homework(-) Monitor & feedback hw(-)
	Opportunity to learn			OTL-biology(-)

Note: (-) negative relationships with science achievement
(s) factor drawn from student questionnaire

Researchers tend to use ‘class size’ from a resource point of view, as discussed in Chapter 3. ‘Class size’ has been shown to influence student achievement (Hedges, Laine & Greenwald, 1994; Greenwald, Hedges & Laine, 1996; Blatchford et al., 2007) and the impact was greater in particular for younger, disadvantaged, and minority students (Mosteller, 1995; Rice, 1999). This is the case in South Africa. Nonetheless, it operates in reverse in Korea, unlike in other countries. A larger class in Korea has a more positive impact on achievement, a possible reason being that Korean parents who place a high value on education tend to move to more prestigious school areas, leading to overcrowded classes. Therefore, it is assumed that ‘class size’ is related to ‘high expectation’ in Korea. ‘High expectation’ was presented in more detail in the second question.

Research reported high expectations from the school, community, and home in turn have a bearing on student achievement (Phillips, 1997). The current research confirmed this finding at the classroom and school levels in both countries.

A further result emerging as significant has to do with the number of allocated science periods. It is not surprising that the more periods science teachers teach per week, the better their students score. The maximum number of periods a teacher in Korea takes per week is limited to 24 by regulation, including home run[15] and club activity[16], and four periods of science lesson per week taught in every class in Grade 8. Therefore, taking fewer science periods means that more time is assigned for administrative tasks other than teaching. It was also documented that time for teachers to plan and prepare lessons with other instructional resources had a statistically significant impact, in particular on teachers' investigative practices (Supovitz & Turner, 2000). Jita (1998) argues that science teachers might not be able to devote sufficient time to prepare adequately for effective teaching when they are distracted by other subjects.

As regards teaching practice, ‘practical learning’, ‘STS learning’, and ‘lecture learning’ were found statistically significant in Korea. In particular, ‘lecture learning’ was more significant than other practices. It might be because teacher-centred practice like ‘lecture learning’ is well-organized and thus students at the stage of schooling tested may acquire knowledge and skill efficiently (Kupari, 2006). Another explanation can be that students under more hierarchical cultures may learn better where being taught in a more directly explicit approach, as Fradd and Lee (1999) put forward. In contrast, in South Africa, STS-based teaching and practical teaching showed negative relationships. This may be an indiction that these practices are handled at a superficial level,

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[15] Home run: each class is allocated to a teacher and the teacher is supposed to take a period per week for the class.

[16] Club activity: many club activities are presented to students and each teacher is in charge of one club. A period per week for club activity is allocated in Korea.

possibly resulting from insufficient preparation of South African teachers to implement the learner-centred practices of the curriculum (Rogan, 2004; Rogan & Aldous, 2005).

In terms of time dimension, the results showed a complex picture that cannot be interpreted directly. Specifically, homework-related factors showed a negative relationship with student achievement in South Africa. Given that teachers use homework differently, depending on the grade, and thereby the relationship between homework and achievement varies across subjects and grades (Van Voorhis, 2003), it might indicate that teachers in South Africa use homework for lower performers to make up their study.

As presented above, Korea has fewer factors to influence student achievement at the classroom level as opposed to many factors in South Africa. Furthermore some of them, viz., teaching practice or time for learning in South Africa, need to be researched further as they show reverse results against findings reported in the literature.

3. Which factors at the school level influence science achievement?

From the preliminary analyses, ten factors were identified at school level in Korea compared to 17 in South Africa as shown in Table 9.3 (below). School size, referred to as ‘all grades’, ‘eight grades’, and ‘computers at school’[17], is important in Korea. This can be explained in the same as in ‘class size’ (see sub-question 2 above), where more students indicate popular schools, reflecting higher expectations of parents and students.

Community size is important in Korea and South Africa. It was reported globally that school location has a bearing on student achievement, indicating urban areas performing better than rural areas in both developed and developing countries (Phillips, 1997; Webster & Fisher, 2000; Bagata et al., 2004; Reddy,

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[17] One computer is allocated to each teacher and each class in Korean schools, therefore number of computers at school may be seen as a proxy of school size.

2006). The community around a school can influence students in many ways. For example, students attending a school with more advantaged students may have high expectations from the school, community, as well as home (Phillips, 1997; Howie et al., 2008).

Table 9.3 ***Factors significant at the school level***

Levels	Effective factors		Korea	South Africa
School	Quality	Curriculum management		
		Professional teaching force	Professional development	Professional teaching force Administrative duty Supervise & evaluate(-)
		School climate	All grades & Eight grades Community size Disadvantaged & Advantaged Educational ethos Frequency of bullying Severity of disrespect(-) Computers at school	Safe school(s) School environment(t) All grades & Eight grade Community size Absenteeism(-) Student still enrolled Disadvantaged(-) & Advantaged 1st language High expectation Parent involvement(-) Severity of low morale(-)
		Resources		Material resource(-) Facility resource(-)
	Time			
	Opportunity			

Note: (-) negative relationships with science achievement
(s) factor drawn from student questionnaire
(t) factor drawn from teacher questionnaire

In terms of student behaviour, it was documented that an orderly school atmosphere and a positive disciplinary climate, are conducive to student learning (Good & Brophy, 1986; Mulford, 1988). It is confirmed that schools in Asian countries are orderly with well-organized discipline. However, 'severity of disrespect' for teachers revealed a significant and negative impact on achievement in Korea. Considering the heritage of Confucianism, this might reflect Korean educational culture changing from a hierarchical system where teachers were regarded as high-educated individuals and respected by parents and student in the past.

With respect to professional teaching force, ‘professional development’ in Korea and principals’ leadership (administrative duty, supervision and evaluation) in South Africa were found as significant along with ‘professional teaching force’. It was documented that high-quality professional development changed teaching practices and improved student learning (Kahle et al., 2000; Supovitz & Turner, 2000; Desimone et al., 2002). In addition, education leadership was proved as significant in SER (Edmonds, 1979; Mulford, 1988; Scheerens & Bosker, 1997; Tate, 2001). These two issues will be discussed further in the second main research question.

Some findings identified mainly in developing countries are found in the South African results. Considering the negative association of absenteeism and the positive association of student enrolment (student still enrolled), attending school is a challenge to South African students. It was documented that students from educationally and economically poor-resourced homes tend to go to school later than supposed, or to drop out of school (Mzamane & Berkowitz, 2002, Fiske & Ladd, 2004). Resource-related and SES-related factors showed significance and discussion is presented in the second question.

As Fraser (1989) stated, student achievement is influenced by a number of factors rather than by a single dominant one. Tables 9.1, 9.2., and 9.3 (above) contrasted the factors identified in both countries to the research framework developed in Chapter 4. The next section elaborates on how different factors contribute to student achievement.

Question II: To what extent do the factors derived from the analysis explain the differences in the achievement of Korean and South African students?

The second main research question, given above, was divided into four sub-questions which were explored using correlation analyses as well as multilevel analyses. The results of multilevel analyses can be mainly examined as significant factors that improved the model, thus providing a much clearer picture in terms of differences between the two countries (Table 9.4, below):

Table 9.4 ***Predictor variables identified from multilevel analyses***

Levels	Effective factors		Korea	South Africa
Student	Time on task		Extutor, timafsch	Extutor(-)
	Opportunities used			
	Student characteristics	Aptitudes towards science		
		Attitudes towards science	Liksci	Selfcon
		Social context	Bokhom, edudad, edustu	Agestu(-), boncnty, languag, hompos, media
Classroom	Instructional quality	Science curriculum		Textuse(-)
		Teacher background		Agetch, 1stdeg
		Teaching practice		STS(-)
		Classroom climate	Hixpect	
		Physical resources		Phyres(-), clasize(-)
	Time for learning			
	Opportunity to learn			
School	Quality	Curriculum management		
		Professional teaching force	Prodeve	Admindt, supevdt(-)
		School climate	Schsize, disadva(-)	Disadva(-), lomoral(-), safschag(-)
		Resources		
	Time			
	Opportunity			

Note: (-) negative relationships with science achievement

As seen in Table 9.4, a single factor was found significant at the classroom level in Korea compared to many factors in South Africa. The student and the school levels also have more factors that are significant in South Africa than in Korea. Similarities and differences between the two countries are discussed below, corresponding to the answers of sub-questions.

1. Which factors influencing achievement are generic when comparing Korea and South Africa?

Some factors were generic in both Korea and South Africa. Firstly, at the student level, attitudes towards science (liksci, selfcon) are the strongest predictors of science achievement between individuals in both countries according to the results of multilevel analyses. This result also confirmed previous findings reported in the literature (Kahle et al., 2000; Shen & Pedulla, 2000; Papanastasiou & Zembylas, 2004; Chang & Cheng, 2008; Howie et al., 2008; Shen & Tam, 2008). In addition, it is consistent with Shen and Tam's finding (2008), that high-achieving countries tend to have negative attitudes and low-achieving country positive attitudes.

At the school level, percentage of disadvantaged students (disadva) is important in both countries. As for the relationship between SES and achievement, it has been well documented in SER that it is likely a stronger predictor at the school level than student level (Beaton & O'Dwyer, 2002). It was reported that the SES of a school (the proportions of students receiving free or reduced lunch was used as a proxy) influenced teaching practice more than either principal supportiveness or available resources influenced teaching practice (Supovitz & Turner, 2000). Therefore, students attending schools having more advantaged students can benefit in many ways. For example, the high expectations from the school, community, as well as home (Phillips, 1997) figure strongly. Students have more opportunity to learn content as the school offers more content and highly-qualified teachers than do ones in disadvantaged areas (Ramírez, 2006).

2. Which factors influencing achievement are specific to Korea?

At the student level, Korean data revealed that educational resources in the home influence student achievement. The results show that the father's education (edudad), school level expected by the student (edustu), books at home (bokhom), and computer use (comsue) are significant in contributing to the model. This is consistent with research that found home background, in particular educational resources offered in the home, a strong predictor of science achievement (Von Secker, 2004). Furthermore, international studies conducted by the IEA consistently showed that 'books at home' have a positive relationship with student achievement (Comber & Keeves, 1973; Postlethwaite & Wiley, 1992; Beaton et al., 1996; Martin et al., 2000; 2004).

With respect to time on task, out-of-school activities (timafsch) are significant as expected from the review in Chapter 3 in which more time on task is associated with student achievement. In particular, Korean parents force their children to take extra tutoring in private institutes, called '*Hakwon*', after school. Some of the students spend more time on extra tutoring than at school and it has been a very contentious issue in Korean society. Nonetheless, from a teaching and learning perspective, it is obvious that more time on task increases achievement (Carroll, 1963; Fraser, 1989; Šetinc, 1999).

At the classroom level, 'high expectation' (hixpect) remained significant, as seen in Table 9.4 (above). It is argued that teachers' high expectation towards students in class can be one of the ways that facilitate and raise students' self-concepts (Muijs et al., 2005). Research reported that a very low academic self-concept is likely to impair an individual's performance, while over-optimistic perceptions of one's performance resulting from low teacher expectations may reduce a student's devotion and subsequent performance (Stevenson et al., 1990; Stevenson & Stigler, 1992). It is clear that 'high expectation' can develop classroom climate which in turn develops a positive student attitude and thereby achievement, reflecting the zeal for education particularly in Korea.

At the school level, 'professional development' (prodeve), and 'school size' (schsize) are specific to Korea. From a policymaker's perspective, no alterable ingredient has impacted on student achievement except for professional development at the class/school level. High quality of professional development improves teaching and prepares teachers to meet the diverse needs of today's students, and subsequently closes achievement gaps (Kahle et al., 2000; Supovitz & Turner, 2000; Desimone et al., 2002). High quality of professional development in science can be guaranteed where providing intensively and steadily and immersing teachers in inquiry-based tasks. It also should involve concrete teaching tasks based on subject matter knowledge (Supovitz & Turner, 2000).

'School size' remained significant in Korea (Table 9.4, above). As was the case of 'class size', 'school size' should be considered in terms of educational expectations in Korea, as parents with higher zeal for education tend to move to more prestigious school areas, leading to large schools. Therefore, in Korea, a large school means students have more educational zeal. On other hand, generally, schools in urban areas tend to have more students than in rural areas in Korea. Therefore, it is understandable that larger schools performed better.

3. Which factors influencing achievement are specific to South Africa?

At the student level, 'student age' (agestu), 'language at home' (languag), 'home possession' (hompos), 'born-in country' (boncnty), and 'media' (media) are specifically significant in South Africa (Table 9.4, above). Whilst educational factors are important in Korea, ethnicity factors and SES factors are more significant in South Africa.

Some researchers documented that minority-ethnic groups performed less well than majority groups (Hamilton et al., 1995; Adigwe, 1997; Klein et al., 1997). This phenomenon is understandable as students from minority ethnic groups have to learn science knowledge in an instruction language that is different from mother tongue (Rollnick, 2000). The language barrier also holds true for South Africa, with 11 official languages and where language was found to be a strong predictor of student achievement (Howie, 2002). As the language of instruction is often different from the language spoken at home, it consequently prevents students from understanding subject content and hampers communication and thus teaching and learning. Given that reading ability had a strong relationship with achievement in science (Brookhart, 1997), it is evident that students who are not familiar with the language of instruction cannot understand knowledge taught in class.

According to Walberg's productivity model (1990), which includes learners' biological development as one of the effective factors, older students should perform better than younger ones as they are readier to learn. Student age in South Africa, however, has a positive relationship[18] with achievement. The older the students the less well they performed. Taking with home possession, which has a positive relationship with achievement, it might indicate students from educationally and economically poor-resourced homes do not attend school regularly or go to school later than supposed. As a result, they have less opportunity to learn and have to repeat grades because they failed to pass the standard demanded by the curriculum (Mzamane & Berkowitz, 2002, Fiske & Ladd, 2004).

Of relevance to this study is that 'media', representing 'watch TV or video' showed a positive relationship with science achievement in South Africa. This indicates that the mass media not only provides information related to science but also helps students improve their English. A similar result was found in Howie's study (2002) on mathematics in South Africa, where listening to the radio showed a strong relationship with student achievement. Walberg (1990) included mass media environment such as television or video in nine effective factors that influence student outcomes negatively.

The classroom level has even more significant factors specific to South Africa than does Korea, notably textbook use (textuse), teacher age (agetch), teacher qualification (1stdeg), 'STS'-based teaching, physical resource (phyres), and

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[18] Young students were assigned the higher score and the elder students the lower score. Therefore, the positive relationship indicates younger students performed better.

class size (clasize). With respect to the science curriculum, textbook use (textuse) is significant in South Africa, however the use of textbooks showed a negative relationship to performance. This was a surprising result, because in terms of opportunity to learn, textbooks can provide content of what should be taught in classrooms (Valverde & Schmidt, 2000) as well as the methods employed. In terms of resources, this might be an effective way to access scientific knowledge, particularly in developing countries (Fiske & Ladd, 2004). Most of the science teachers sampled in South Africa (92%) indicated that they used textbooks, with 63% using them as supplementary resources and 37% as primary resources. 'Textbook use' should have a positive effect as scaffolding to build scientific knowledge. The negative impact might be an indication that teachers used textbooks without reconstructing content for students to make meanings for themselves.

Another possible explanation might be that the outcome-based curriculum followed in South Africa, which does not prescribe content to be taught, but outcomes to be obtained by students, is not being implemented appropriately as pointed out by Rogan (2004). Furthermore, considering that teaching practice such as 'practical work', which is recommended for effective group learning by researchers (Harskamp & Ding, 2006; Odom et al., 2007), operates in an opposite way to general research findings, it is evident that outcome-based teaching and learning does not improve achievement at the classroom level. This may be related to inadequate preparation of South African teachers to implement the outcomes based curriculum.

Teacher qualification and age are significant in South Africa, with Heyneman and Loxley (1983) having found that teacher quality along with school quality was more important in developing countries. Teacher quality is also important in the light of 'opportunity to learn' (Ramirez, 2004). In terms of equity, as teachers tend to teach what they know, those who lack background in science are more likely to reduce coverage of content, which leads to difference in the implemented curriculum (Ruby, 2006). Specifically, the more disadvantaged students are taught by the least qualified teachers, hence perpetuating a vicious cycle of poor education in less developed countries such as South Africa (Howie, 1999; Ramirez, 2004).

Besides teacher qualification-related factors, resource-related factors (phyres and clasize) are significant in South Africa, confirming the findings of Fuller (1987) that material inputs are related to achievement in developing countries. As Scheerens (2001) put forward, material and human resource factors showed strong effects in developing countries such as South Africa compared to developed countries. It is proposed that the current finding also reflects the backlog resulting from unbalanced financing support under the apartheid regime. Although the disparate financing policy was diminished after the 1994 democratic elections, it is clear South African education is still struggling with ‘a cycle of mediocrity’, controlled by poor resources and under-qualified teachers (Howie, 1999).

At the school level, educational leadership (admindt and supevdt), safety in school (safschag), and student morale (lowmoral) are good predictors of student achievement in South Africa. Educational leadership has been proved to influence student achievement since it was identified within effective schools in early SER (Edmonds, 1979; Mulford, 1988; Scheerens & Bosker, 1997; Tate, 2001). South African results showed a school performed better when the principal was involved in administrative duty rather than supervising and evaluating teachers. According to previous findings (Creemers, 1994; Reynolds et al., 2002), it is evident that where educational systems are more decentralized, less engineered, and less ordered, principals’ leadership is more important than in centralised and better organised systems. It was found that South Africa schools were closer to the former.

As Harber and Muthukrishna (2000) suggested, SER should reflect a specific country’s educational, cultural, and social contexts. For example, non-violence is an issue in South Africa as the results revealed safety in school is significant.

According to the results of multilevel analysis, ‘safety in school’ is the strongest predictor of science achievement at the class/school-level, explaining the high variance between schools in South Africa. According to UNICEF (2000), quality education environments are healthy, safe, protective and gender-sensitive. It is clear that a secure environment is a prerequisite for high achievement.

Lastly, ‘severity of low morale’ was found significant in South Africa. It is possible that low morale of students reflects the culture of resistance to education, specific to South African history. Admittedly, the long period of Bantu education (40 years) contributed to the total collapse of the teaching and learning culture in South Africa (Fiske & Ladd, 2004). Although the new democratic government has made an effort to rebuild a positive perception of education, it still has a long way to go.

From the research, it is clear that factors specific to South Africa reflect the country’s educational context accurately with regard to factors relating to ethnicity, teacher qualification, and resources. These findings are confirmed by the results of multilevel analyses. In particular, the results of the South African data are largely in accordance with previous findings that science achievement is more likely to be influenced by school and teachers than students’ social status (Heyneman & Loxley, 1983).

4. How do these generic and specific factors explain the difference in the performance of the two countries?

Overall, Korean and South African students differ in terms of science achievement as well as in terms of the factors identified as strong predictors of it. According to multilevel analysis, the null model was used to partition the total variance in science achievement in each country into its within-classroom and between-classroom/school variance components. The Korean null model without any explanatory variables revealed that 93% of total variance in science achievement occurred at the student level, while only 7% of the total variance was attributable to the classroom/school level.

The student model, which has all student-level variables only, accounted for 31% of the achievement variance at the student level and 74% of the class/school-level variance, while the class/school model, in which class/school-level variables are added, explains 87% of the variance at the class/school level in Korea, where it is clear that the student-level variables explain a considerable amount of class/school-level variance.

The South African results of multilevel analysis show that 41% of the total variance in science achievement were assigned at the student level and 59% at the class/school level in the null model without any explanatory variables. The student-level model accounted for 20% of the variance occurring at the student-level and 54% of class/school-level variance, while the class/school model explains 89% of the variance occurring at the class/school level. Student-level variables do not explain as much of the class/school-level variance as in Korea.

In sharp contrast with the finding that, according to the null model, only 7% of the variance in student achievement was accounted for at the class/school level in Korea, more than half of the variance (59%) in achievement occurs among schools in South Africa. As a result, the model built in the research gave a different picture from the Korean picture. Some 59% of the variance is attributed to the class/school level in South Africa. This result is consistent with the research conducted previously in South Africa (Howie, 2002, Scherman, 2007), and the same finding is prevalent in developing countries.

The small percentage of between-classroom/school variance explained (7%) means that Korean classrooms or schools are homogeneous and have mixed-ability students, given that the amount of variability within- and between-classrooms/schools indicates the homogeneity of the classrooms (O'Dwyer, 2005). There is no tracking in lower-secondary school level (middle schools) in

Korea, while vocational or technical education runs parallel to an academic track in high schools. It was found that a substantial proportion of the variation among students occurred between schools in the study involving higher-secondary schools (high schools) in Korea, reflecting their being tracked due to achievement and SES (McGaw, 2005).

On the other hand, the large percentage of between-classroom/school variance explained (59%) indicates it might result from residential segregation due to race and SES, which is associated with variations in achievement (O'Dwyer, 2005).

The percentages of variance explained by the multilevel models demonstrate that the variables included in the models have varying capacities for predicting science achievement in different countries. The results show that in both countries the models are more powerful for predicting differences between classrooms/schools than for predicting differences within classrooms. In Korea, the final model explained 87% of the variance between classroom/school, and 89% in South Africa, compared to 31% of variance occurred within-schools in Korea and 20% in South Africa respectively.

Korea and South Africa differ in the context of education and culture, but some factors are similar, particularly in their apparent influence on science achievement, but with a subtle difference. For example, 'attitudes towards science' is the strongest predictor of science achievement at the student level in both countries. At the class/school level the percentage of disadvantaged students is the strongest predictor in Korea and safety in school in South Africa. In particular, student social context such as ethnicity, age, and language, and teacher background such as qualification and age are significant in South Africa. In many respects the results of the study are consistent with prior research, although there are some opposite results, including the negative effect of textbook use in South Africa.

9.3 DISCUSSION AND REFLECTION

This section summarises the discussion and reflection of the findings derived from the research. The research framework is discussed and reflected on (9.3.1), followed by a review of school effectiveness research (9.3.2). The methodology used in the research is discussed (9.3.3), the section concluding with the contribution to scientific and practical knowledge (9.3.4).

9.3.1 REFLECTION ON THE CONCEPTUAL FRAMEWORK

The current research began by building a conceptual framework based on previous studies and proposing a model for effectiveness of science education (Figure 9.1, below). The conceptual framework was based on a particular learning and teaching theory, initiated by Carroll (1963), and proposing five factors, namely students' aptitude, perseverance, ability to understand instruction, quality of instruction, and opportunity to learn. It has been argued that educational research and the findings do not fit teachers in the field because those findings are more likely to represent deep and micro aspects than the reality in which teachers work (Duit & Treagust, 2003). Furthermore, teachers not only need to consider learners from a micro level perspective, such as conceptual change, but also to take into account the environment surrounding students and themselves at the macro level, namely physical factors. For that reason, the model for effective science education should be based on teaching and learning theory as well as physical environments. Therefore, the conceptual framework for the study covers many aspects, such as human, material, and time, as shown in Figure 9.1 (below):

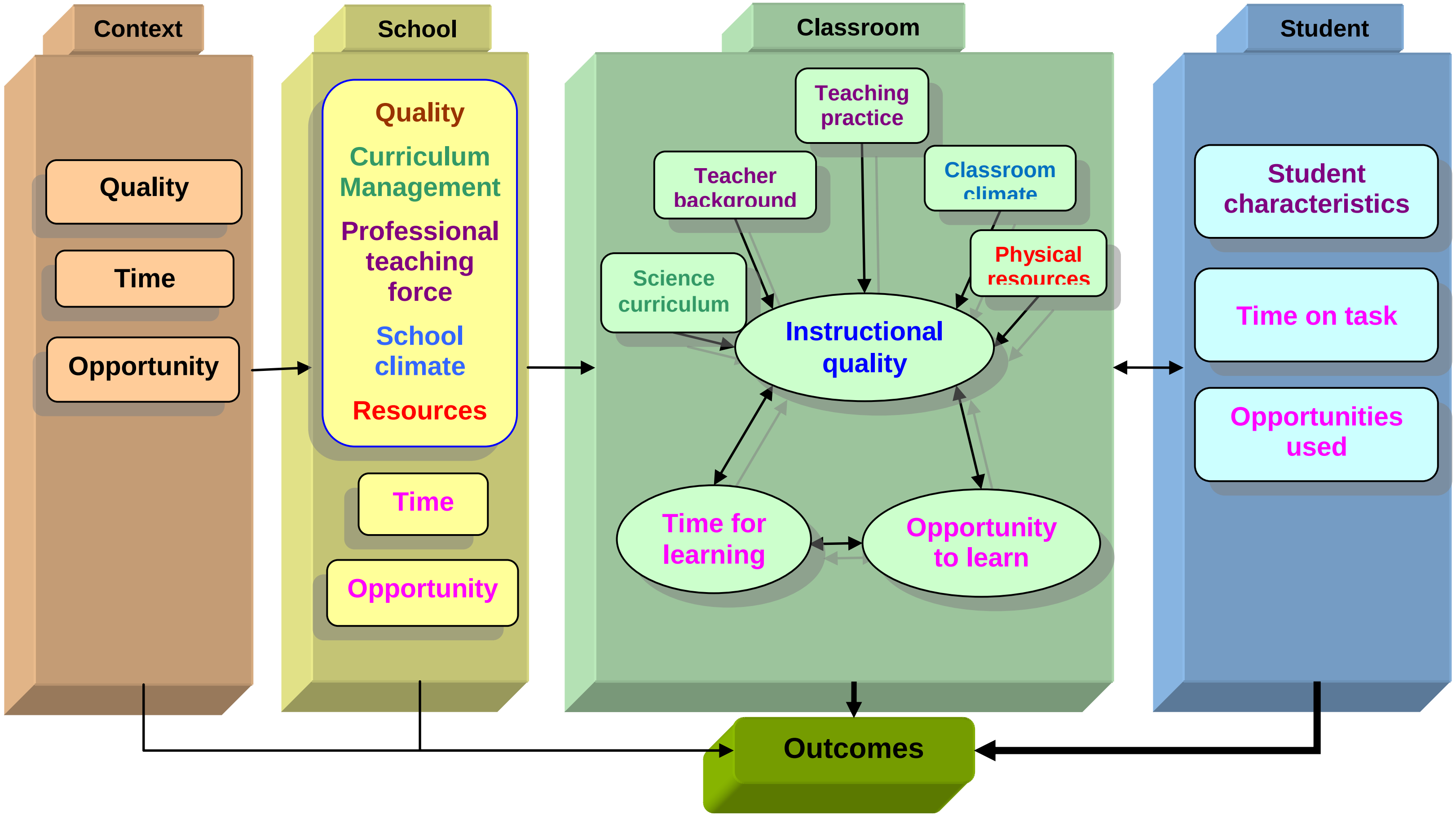

Figure 9.1 **A proposed model of effectiveness of science education**

Some modifications can be made on the model formulated from the conceptual framework according to the findings. Models modified for Korea and South Africa are illustrated in Figures 9.2 (below) and 9.3 (below) respectively. It should be noted that the model adapted from the analysis of the data was limited to the two countries and the research used a two-level hierarchical linear model (i.e., students nested within schools), as TIMSS tested only one class per school sampled.

The models shown in Figures 9.2 and 9.3 include variables (factors) identified as significant in the multilevel analyses. Compared to many factors (variables) examined at the beginning of the study, only a few have emerged as significant to student achievement in science, this being more likely the case in Korea.

The conceptual framework focused on three key factors influencing student achievement, namely time, opportunity, and quality. *Time* indicates students' time on task, teachers' time for teaching and learning, and instructional time allocated by school regulation. *Opportunity* covers learning opportunity used by students, teachers' opportunity to teach, and opportunity provided by school (Creemers, 1994). *Quality* includes student background, teacher and teaching background, and school support for teaching and learning (Reynolds & Walberg, 1991; Freedman, 1997; Mayer et al., 2000). From the results on the whole, and comparing them with the framework, in particular, time (extutor) at the student level was important. In contrast to time, although topic coverage was comprehensively asked of teachers at the classroom level, opportunities used or opportunity to learn were not identified as important at each level in Figures 9.2 or 9.3. Within the social context of students, attitudes towards science (liksci, selfcon) were significant in both countries, and with other social contexts, educational factors are important in Korea and ethnicity and SES – related factors matter in South Africa.

At the classroom/school level in the multilevel model, high expectation (hixpect) and teachers' professional development (profdeve) are vital in Korea, whilst teacher qualification (agetch, 1st deg) and physical resources (phyres) are important in South Africa, as expected from the previous studies. In addition, science curriculum (textbook use), principals' roles, safety in school, and students' morale are significant in South Africa.

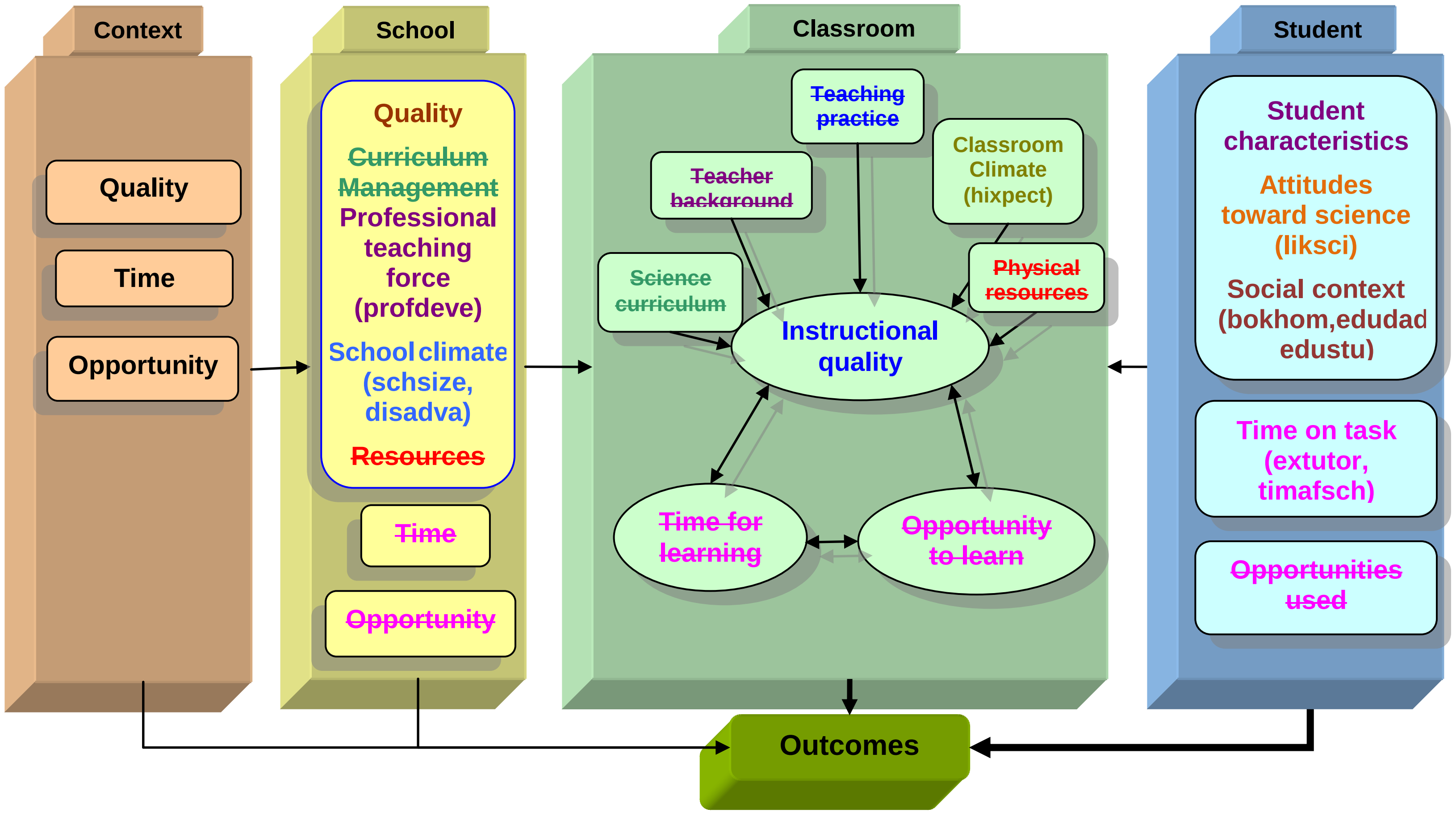

Figure 9.2 **A model of effectiveness of science education for Korea**

Note: Strikethrough font indicates factors which are not significant.

The Korean model differs from the South African one particularly in terms of instructional quality. South Africa has more factors overall that account for the variance in student achievement in science when comparing Figures 9.2 and 9.3. Such a difference is not surprising, taking account of the difference between the two countries in many aspects such as demography, culture, and history. It was documented that even though the same model is applied for other grades or subjects within one country, the results are different (Reynolds & Walberg, 1991; 1992). This is even more likely the case in different countries, where the major factors cannot hold for every one. Stevenson and Lee (1990) contend that factors predicting differences in performance within a given culture may not be the same as those that predict differences in individuals between cultures, and this appears to be true of the present study in light of differing educational systems.

Therefore, factors influencing student achievement should be considered, taking account of the status quo of an educational system or country. It is sufficient to note here that a spatial and temporal locality of the relationship applies to all the factors influencing student achievement as well as to attitudes towards science, as suggested by Papanastasiou and Zembylas (2004, p.259).

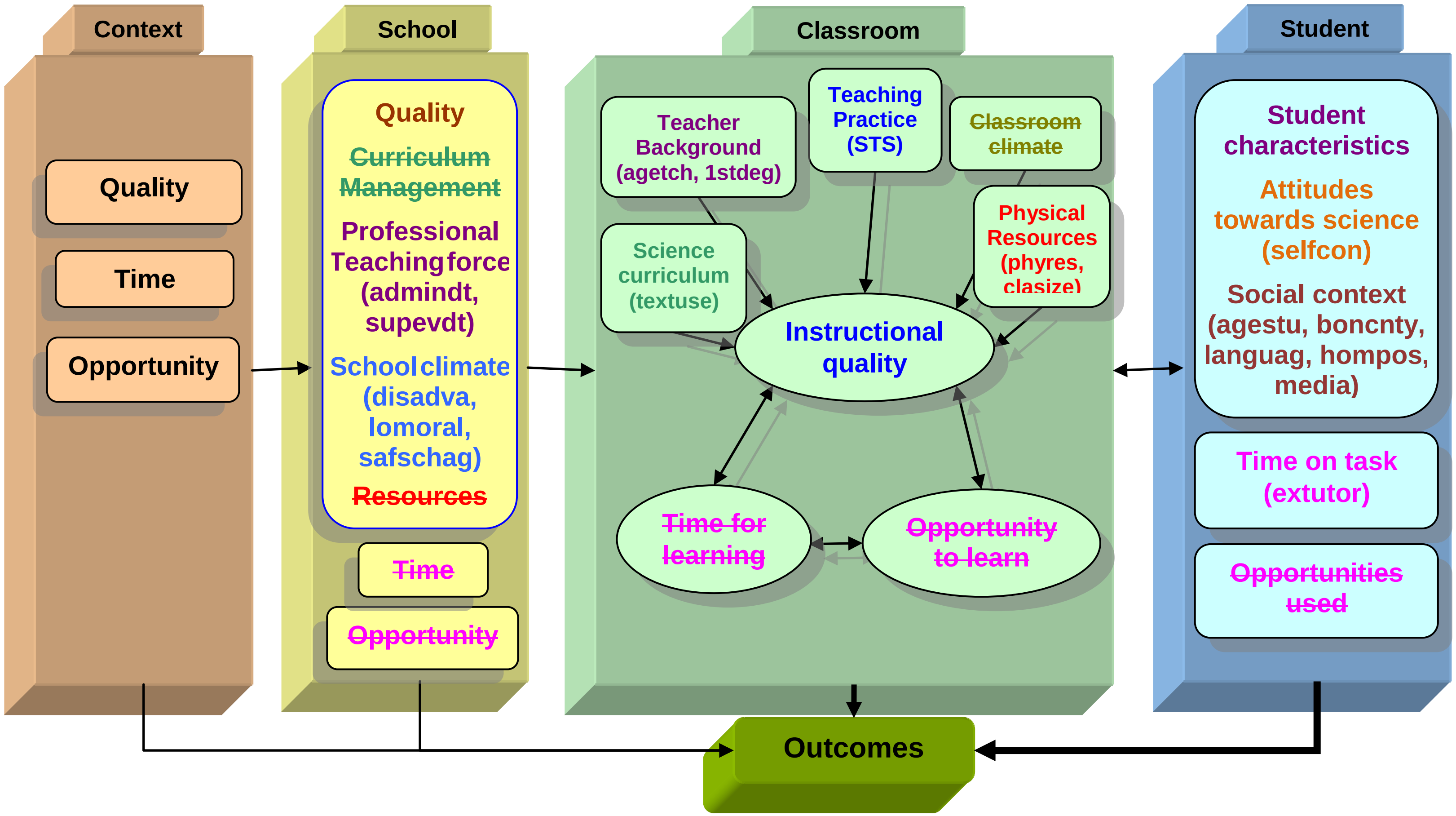

Figure 9.3 **A model of effectiveness of science education for South Africa**

Note: Strikethrough font indicates factors that are not significant.

9.3.2 REFLECTION ON SCHOOL EFFECTIVENESS RESEARCH

The results of the study can contribute to School Effectiveness Research (SER) from an economical development point of view, by comparing a developed and a developing country. SER has become one of the most important domains of education research during the past three decades (Teddlie & Reynolds, 2000). SER assumes that students' achievement represents the effectiveness of an education system, or to put it broadly, the quality of education. For that reason, stakeholders or policymakers tend to provide more input, such as budget or resources to improve their education system in terms of outcomes.

In contrast, many studies pertaining to students' outcomes have found home characteristics to be more highly associated with student achievement than school characteristics. As a result, a great deal of research has highlighted the need to examine the influence of students' background characteristics when examining student achievement. However, it does not hold true around the world, in particular in less-developed countries. As found in the study of Heyneman and Loxley (1983), it is often accepted that the economically developed countries show the pattern of larger influence by family SES with smaller school impact, and the reverse pattern in less-developed nations. The current research confirmed the Heyneman-Loxley effect empirically from the results of Korea and South Africa. As Scheerens (2001) stated, there are considerable differences between schools in South Africa, whereas the effect of school is minimal in Korea. In addition, material resources and teacher background are important in South Africa, unlike in Korean results.

Nonetheless, the results from the two countries should be viewed not only from an economical development perspective, but also from a cultural one, given that the current study involves one country from Asia and another from Africa. The two countries are different in many respects, such as economy, education, history, culture, and demography. Therefore, the differences between the results should be interpreted from a cultural perspective, and take into consideration unique contexts. Comparisons should be made to determine not which one is better but how each educational system works in different contexts. For example, high expectation in Korea can be explained from the heritage of Confucianism, which values highly educated individuals. Language and low morale of students in South Africa should be interpreted with the backdrop of an apartheid past which still hunts the education system.

However, if educational researchers or practitioners make interpretations without considering cultural differences and try to apply these to other contexts, and if policymakers and stakeholders intend to roll-out interventions which neglect cultural differences and simply try to implement what is developed elsewhere, they will make no improvement (de Feiter et al., 1995).

SER also recognized that school effectiveness varies across subjects. Nonetheless, SER tends to use language or mathematics as outcomes. By using science achievement the study made a contribution to the discussions based on literature. It is commonly accepted that science varies greatly in terms of curriculum, compared to mathematics which is more standardized across the countries. In terms of variance explained, the current study did not identify any findings that were different from the previous studies on mathematics conducted in Korea and South Africa. In lower-secondary school level, a larger portion of variance is explained at the student levels in Korea, but at the school level in South Africa, which are concurrent with the results of previous research. Specifically, some different factors were identified in each country, for example, computer use in Korea and educational leadership in South Africa. However, it should be noted that the above comparisons of studies are not exactly the same in terms of methods and variables selected.

On the other hand, the current research developed the conceptual framework from SER based on an economic input-output paradigm as well as classroom/school processes, which are regarded as a ‘black box’[19] (Black & Wiliam, 1998). The results of the study ascertained some factors significant at the classroom and school levels as follows: professional development, high expectation, educational leadership, school SES, instructional resources. Nonetheless, no factor was found in particular in terms of teaching practice, which is considered as influencing

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[19] It means literally the content remains unknown. Although learning and teaching take place actually in classroom, one do not know exactly what and how works for student outcomes.

student learning directly. It is assumed that impact of teaching practice needs to be approached by a micro-level framework under a macro–level model, such as the model adapted in the study. It might be too ambitious to expect one model to detect every factor.

9.3.3 REFLECTION ON METHODOLOGY USED

The research is a secondary analysis that used a large dataset of high quality collected in TIMSS 2003. Therefore, the researcher could save time and cost in collecting sufficient data and instead focus on data analyses. However, there are some disadvantages where a secondary analysis is used. The main limitation was that the researcher could not include everything necessary as the data had already been collected, and some factors that seemed significant from literature could not be explored because the data did not support it. Specifically, as TIMSS collected data in cross-section, the study could not use any on aptitudes (prior knowledge), which is proof of some variance in outcomes.

Although TIMSS provided information for the study, there are some risks to aggravating scales, as TIMSS collected information about some important factors by only a few items and survey. Admittedly, factors may not be measured in totality by one item (Bos, 2002). Another limitation, especially in survey research, is the issue of socially desirable responses where respondents answer in a manner expected, and which may not be reflective of their teaching practice (McMillan & Schumacher, 2006). In addition, for some factors the clustered sets of items differed in the two countries when constructing scales. A possible explanation for the differences is that cultural differences may result in different interpretations of the same questions between the two countries. As a result, differences in the reliability coefficient as well as of the clustered sets of items for some variables, implies that the power of comparability between the two countries might decrease (Bos, 2002). Therefore, there is a need to improve internal consistency and thus enhance the international validity of factors. In the process of the design of an international comparative study, a pilot test of background information should be prepared with more precision, and including more items could be another way to improve the validity of factors. Fundamentally, a conceptual framework firmly based on empirical and theoretical findings should guide the design of the study through all the processes.

On the other hand, the research was primarily exploratory in nature and was reflected in the research design, which consists of factor, reliability, correlation analyses, as well as multilevel analyses. However, only direct effects of variables on student achievement were taken into account, by examining the results of factor, reliability, and correlation analysis. The indirect effects can be provided by means of Partial Least Squares (PLS), one of the techniques used to estimate path models. PLS can be recommended in an exploratory study, where data from a complex context such as a school is involved (Howie, 2002). As PLS provides a researcher with the direct and indirect relationships among variables, and the strength, it can be used to make a decision for inclusion in further analyses, such as multilevel ones (Howie, 2002).

Nonetheless, the current study depended on the results of factor, reliability, and correlation analyses when selecting variables for multilevel analysis. As the research built a conceptual framework based on the comprehensive literature review, and the study aimed at contrasting Korea and South Africa, it is assumed that the indirect effects are considered beyond the scope of the current study, and thus PLS might be over-requisite processing. It should however, be noted that there is some risk that while variables assigned to the same factor in the conceptual framework might have slightly different meanings from a micro perspective they could have the same meaning from a macro perspective.

The purpose of the study was to investigate the reasons for differences between Korea and South Africa in terms of science achievement. Accordingly, multilevel analysis was used to explain the variance in achievement. Although multilevel analysis uses various levels of data simultaneously, only two-level models were built because TIMSS provides one set of class data per school tested. This means classroom and school cannot be stratified in terms of data collected, however at least two classrooms should be sampled per grade within a school in order to build a three-level model.

In a three-level model, the reliability of estimates of school effect depends on the extent to which teachers within a school are homogeneous in terms of their teaching practices. If between-teacher variability is substantial once student variability is controlled, a three-level model analyzing the instructional effect on students nested within classrooms, nested within schools, could provide a better estimation of the instructional influence on science achievement (Von Secker & Lissitz, 1999). Nonetheless, the TIMSS dataset used in the current research limited the study to a two-level model that compounds instructional effect with school effect.

9.3.4 CONTRIBUTION TO SCIENTIFIC AND PRACTICAL KNOWLEDGE

Scientific literacy is becoming more important as science and technology is the core of much industry, and consequently is the foundation of economic growth (Pillay, 1992; Thulstrup, 1999; Schofer et al., 2000; Baker et al., 2002; Hanushek et al., 2008; Murray, 2008). As such, scientific literacy has been given considerable attention for many reasons. From an economic perspective, modern societies need scientifically and technologically literate workforces to maintain their competencies. In a high-tech and democratic society, individuals need not only a basic understanding of science and technology to function effectively as individuals and consumers, but they also need to be able to reach an informed view on matters of science-related public policies and so participate in discussions and decision-making (Duit & Treagust, 2003).

Large-scale international comparative achievement studies such as TIMSS and PISA have played a valuable role in determining the extent of student scientific literacy. With many participating countries in TIMSS being concerned about the disappointing results of students, improving science achievement (which can be referred to as scientific literacy) has become a major issue and focus of science education research. As a result, many intervention strategies were developed during the 1990s, for example from a micro perspective and with the introduction of constructivist approaches to student learning.

However, educational research regarding the teaching and learning of science that has been dominated by basic research in cognitive psychology has been criticised as it seems that the findings are irrelevant to many teachers. Such studies are usually carried out in arranged settings in order to allow strict control of variables (Duit & Treagust, 2003), however, although the current study attempted to overcome such criticisms and to give some in-depth insights in particular to science teachers, the results seem not to directly inform science teachers of the actual practice of teaching and learning. Rather, they provide the higher education level of the two countries with some valuable findings. For example, from the correlation analysis, time scheduled per week has a positive relationship in both countries. This might mean the more emphasis on teaching and the lesson than on other duties, the better the outcomes. The point of importance here is making teachers dedicated to teaching rather than other types of duty. The South African results related to teacher background and teaching practice also show that improving content knowledge should accompany attempts to improve pedagogy, including effective textbook use.

On the other hand, stakeholders, policymakers, and school administrators demand that school science instruction become more effective in terms of school quality. Therefore, illustrating where the variance in achievement occurs can help policymakers better understand the status quo of the educational context in question and implement interventions to reduce the variance. In this vein, the current research can help policymakers find strategies that can increase teachers' ability to use resources such as textbook and students' engagement and interest in science and subsequently promote outcomes.

The current study developed a conceptual framework which mainly draws on the work of Creemers (1994), and Scheerens (1990), supported by a comprehensive literature review. To examine learning processes and outcomes between or among individuals, something must be known about the educational contexts. In this vein, the main idea of the framework was based on the assumption that student outcomes result from hierarchical structures where factors from different levels cooperate. The emphasis is put on time, opportunity, and quality from a perspective of teaching and learning theory. Therefore, the developed conceptual framework can help one examine and monitor educational systems and, subsequently, improve school or instruction effectiveness.

This research is a comparative study that compares achievement in science and effects of contextual factors at the student, classroom, and school levels in Korea and South Africa. The research purposed to provide insight and perspective in understanding the factors that increase learning and achievement in science in both countries. In addition, this research attempted to make explicit how indicators of effectiveness have been chosen and how it operated in the two countries that have different contexts in many aspects. Accordingly, to ascertain the determinants of cross-national variations in student achievement in the two countries is a very difficult task because students in each country are embedded in their own unique social, economic, and cultural contexts (Shen & Tam, 2008).

Nonetheless, the current research can serve vital functions, in line with Bos' (2002) argument that large-scale international comparative achievement studies have five major specific functions, viz., description, benchmarking, monitoring the quality of education, understanding of reasons for observed differences, and cross nation research. Amongst five functions, three can be supported by the current research, as described below.

The description function can be satisfied with describing similarities and differences derived from exploring the descriptive statistics and statistical analysis, as seen in Chapters 6 and 7. Understanding of reasons for observed differences can be met with postulating a model that accounts for the variance between and within schools, described in Chapter 8. The cross-national-research function can be accomplished by comparing predictable factors resulting from the research. Although the functions are fulfilled to a limited extent, useful recommendations can be made to improve science education in each of the two countries.

9.4 RECOMMENDATIONS

Recommendations were made mainly focusing on policies or interventions that can be addressed by policy-makers in the two countries. Recommendations on

Korean science education are put forward (Section 9.4.1), and recommendations made for South African science education (9.4.2). Recommendations on TIMSS are presented in Section 9.4.3 in particular in the light of the conceptual framework. The section concludes with recommendations regarding school effectiveness research (9.4.4).

9.4.1 RECOMMENDATIONS REGARDING KOREAN SCIENCE EDUCATION

In many countries, including Korea, it is likely that high economic growth has been accompanied by large investments in education. Admittedly, the education level of individuals is a good predictor of future socio-economic status in Korea. As such, educational aspiration is rising and becoming competitive. As a result, Korean students have performed better in international comparative studies such as TIMSS. However, although Korean schools performed well in terms of outcomes, they should not be satisfied with current status but rather seek out ways to improve quality of outcomes (Scherman, 2007). Therefore, some recommendations can be made for Korean science education.

Recommendation 1: Improving students' negative attitudes towards science at the context level

Students' negative attitude to science might be attributed to many causes. From a macro perspective the examination-driven university entrance system forces Korean students to work hard. Therefore, most spend time after school on taking extra tutoring to improve performance, more so than on other activities such as playing or sports. Too much time on task leads to students' burn-out and consequently negative attitudes towards learning (Papanastasiou & Zembylas, 2004; Murphy et al., 2006). Therefore, policymakers should develop a programme to reduce students' work while attending school. From a micro perspective, negative attitudes can result from teaching practice in the classroom. It was documented that transmissive pedagogy contributes to students' negative attitudes towards science (Lyons, 2006), and that more student-centred teaching methods can improve attitudes (Odom et al., 2007). Therefore, teachers need to change their practice, as elaborated on in the next recommendation.

Recommendation 2: Sustained and high quality of professional development for science teachers to change their teaching practice.

The research showed that ‘professional development’ at the class/school level influences student achievement. In addition, ‘teacher interaction’ based on ‘discussions about how to teach a particular concept’ or ‘working on preparing instructional materials’ showed a positive relationship with student achievement. Therefore, policymakers should develop a professional development programme or system reflecting such findings. While Korean science teachers are highly qualified in terms of content knowledge, they tend to use traditional teaching practices such as teacher- and lecture-centred teaching, which are not considered useful in developing higher-order thinking ability, although they do contribute to high performance. Therefore, in terms of quality of science instruction, Korean science teachers need to develop pedagogical content knowledge and change their practice to meet students’ needs, namely to not only attain high achievement, but also to develop higher order thinking skills and positive attitudes amongst their students.

9.4.2 RECOMMENDATIONS REGARDING SOUTH AFRICAN SCIENCE EDUCATION

The research revealed that there are many factors in South Africa that should be considered simultaneously in terms of quality education to improve achievement. Policymakers should consider this point and ascertain which factors have higher priority, as well as considering the complex relationships between important factors. However, when educational issues in South Africa are highlighted, factors such as the budget or instructional materials are more likely to show up than factors such as safety, morale, and ethos. Recommendations made here are focused on factors, such as student and teacher background.

Recommendation 1: Improving the teaching and learning culture and environment.

The research revealed that students’ low morale and lack of safety in schools accounted for some of the variance in science achievement in South Africa. There is a need to ascertain whether a culture of resistance to teaching and learning originating from the previous apartheid government still permeates teachers and students attitudes, even after the political changes in 1994, particularly as a safe and favourable atmosphere is a prerequisite for consistent schooling. A safe environment is one of the dimensions determining quality education (UNICEF, 2000), and 'safety in school' was a strong predictor explaining the variance at the class/school level in South Africa. Therefore, policymakers need to promote an ethos that being educated is valuable, necessary and compulsory in a modern and democratic society, hence a safe environment around schools should be cultivated.

Recommendation 2: Improving teachers' content knowledge

The research confirmed that the lack of qualified science teachers is significant in South Africa. It was pointed out that under-qualified teachers are at the core of factors blamed for poor performance of students, along with the poor infrastructure (Naidoo & Lewin, 1998; Howie, 1999). It is evident that a modern, high quality science curriculum and pedagogy cannot compensate for poorly trained teachers. OBE was introduced as an instructional method to redress deficiencies from the inadequate policies of the past government (Spady, 2008). Despite the high level of responses from South African teachers about science as conducting scientific investigation by many ways, practical work or STS work showed a negative relationship with student achievement. Pinto and Boudamoussi (2009) found the more familiar science teachers were with the underlying scientific knowledge, the more willing they were to take account of the diversity of scientific process such as describing, explaining and predicting scientific phenomena, understanding scientific investigation, and interpreting scientific evidence. Therefore, policy should be developed to improve content knowledge of teachers to improve the quality of science education.

Recommendation 3: Improving student fluency in the language of instruction.

Language is important in science education in the light of social constructivist theory, which contends that students can scaffold knowledge based on language-based social interactions (Staver, 1998). If learners do not have a good command of the language of instruction, outcomes intended cannot be accomplished. Therefore, the language of instruction needs to be taught from the beginning of schooling so that students can improve it before learning more complex knowledge-based subjects such as science. Furthermore, changing the language of instruction in the middle of primary schooling can cause confusion.

9.4.3 RECOMMENDATIONS REGARDING TIMSS

TIMSS is a large scale international comparative study of student achievement in mathematics and science. TIMSS results can provide participating countries or researchers with knowledge of the extent of progress in educational achievement of mathematics and science, suggesting reasons for differences by comparisons between countries, or improving evaluation of the efficacy of mathematics and science teaching and learning. Researchers and stakeholders are becoming more interested in TIMSS and intend to make use of data provided. Therefore, to benefit TIMSS it may be meaningful to give some recommendations based on the results of the research.

Recommendation 1: Suitability of topic coverage

TIMSS made considerable efforts to determine whether items of achievement tests are appropriate across countries, and thus to ensure their validity, as reviewed in Chapter 2. In terms of content coverage, the curriculum questionnaire, which was not covered in the current research, collected intended curriculum from experts who do not implement but plan curriculum. TIMSS addressed content coverage in teacher questionnaires, but these are not related directly to items tested. Keys (1999) pointed out that TIMSS failed to collect results on the implemented curriculum, which is referred to as opportunity to learn the contents of items tested. Instead, results were only collected on the intended curriculum, which is topic coverage. As a consequence, TIMSS results do not inform users whether or not content pertaining to any specific test item has been covered. As shown in Test-curriculum Matching Analysis (TCMA) addressed in TIMSS, South African students' poor achievement could be accounted for by inadequate opportunity to learn (OTL). For future research, it is recommended that a measure is added that covers this deficit. It is particularly necessary where the study intended cross-country comparisons, because it is very evident that opportunity to learn (OTL) influences achievement and accounts for differences in achievement across individuals and contexts.

Recommendation 2: Instrumentation issue

Besides OTL, if researchers aim to compare the influence of educational processes in different countries, it is more appropriate also to collect data on prior achievement, referred to as aptitude. This can be useful because cross-sectional studies that collect data at one point in time do not guarantee appropriate causal inferences (Bos, 2002). Students' aptitude, which is a strong predictor of achievement in SER, can be addressed by collecting information about prior achievement as well. It is expected that the unexplained variance in achievement at the student level can be better understood when factors potentially influencing achievement are added to a new conceptual framework and subsequently to the questionnaires.

On the other hand, TIMSS cannot increase the number of items unlimitedly in order to obtain information needed, due to the constraints of cost and time. To compensate for it, some items that represent the same construct can be removed. For example, there seem to be too many items pertaining to resources or teacher qualification and, among them, only a few items should remain. If some resource-related and teacher qualification-related questions are deleted and replaced by new and necessary ones, the number of questions that respondents should answer will decrease. Consequently, it would not raise the problem of time spent on answering too many questions. In terms of reliability and validity, selection issue was discussed further in the next recommendation.

Recommendation 3: Various data collection methods.

In contrast to a considerable number of variables derived from TIMSS questionnaires that were originally designed to find explanatory factors for science achievement, only a few variables turned out as statistically significant predictors. This could be attributed to survey research in which participants tend to respond with social desirability, undermining the reliability of the responses (Reeazigt et al., 1999). In particular, TIMSS questionnaires allocate a considerable number of questions to teacher instruction, but the data from the questions do not seem to offer plausible information about teaching practice in sampled classrooms. In order to build statistically and conceptually functional scales for the characteristics of the instruction, more items should be addressed, using a variety of methods, including observation (Kupari, 2006). Bos (2002) also pointed out that some of the constructs in the questionnaires should be elaborated on to ensure reliable scales.

9.4.4 RECOMMENDATIONS REGARDING SCHOOL EFFECTIVENESS RESEARCH

Since SER was initiated in the educational research field in the 1960s, it has contributed to evaluation and monitoring of education systems to improve the quality of education. SER involves other research areas, such as teacher effectiveness and school improvement, as there can be various approaches to improving the quality of education. For future SER, some recommendations are proposed below.

Recommendation 1: Multiple criteria as outcomes need to be measured.

Recently, multiple criteria as outcomes are demanded to determine the effectiveness of instruction and of schools. These include basic skills, higher cognitive outcomes, outcomes in different subject areas, and social and affective outcomes (Creemers, 1994). It should be noted that students not only learn cognitive skills but also other things, such as attitudes in their school. Therefore, estimation of school effectiveness by using one criterion shows only a part of all the aspects. It was documented that different kinds of outcomes are influenced by different factors (Hamilton et al., 1995). As the current study used science achievement as outcome, attitudes towards science can also be an outcome to be obtained by students. As quality education has many dimensions, such as learning environment, learning process or learning outcomes, SER needs to designate outcome criteria in many aspects.

Recommendation 2: Country-specific and subject-specific factors need to be considered.

SER should continue to explore generalisations on factors influencing achievement across countries as well as considering specific environments in which an educational system is nested. As shown from the results of the current study, some factors are common to both countries and others specific to a particular country. In particular, specific factors are more likely to reflect on the specific situation in which an educational system in question is placed. For example, watching television or video reduces time on task in Korea while it supports student learning in South Africa. In addition, taking into account that subject-specific factors such as computer use is important in Korea, SER should seek not only generalization but also specification across countries and subjects.

9.5 CONCLUSION

Having a first glance at TIMSS tables summarising mean achievement in science, it is clear that Korea outperformed South Africa in consecutive studies. However, before any interpretations or conclusions are made by the information illustratively presented in TIMSS only, it should be considered that countries such as Korea and South Africa examined here differ with respect to many social and educational contexts, such as culture, history, and demography. There is no doubt that these differences affect the amount of observed variability in science achievement among students in each context. It is against this backdrop that in-depth research such as the current study is necessary to fully utilise TIMSS data.

Cross-national studies in education, such as the current one, provide researchers with an opportunity to examine how students in both similar and different formal education systems perform in the same test, and give abundant information about the relationships between student achievement and the factors influencing them. Under the assumption that the two countries can learn from each other, this comparative study between Korea and South Africa purposed to provide valuable information for improving the prediction of students' science achievement in the two countries. However, in order to learn from other educational systems, one should keep in mind that there is no single education method that best suits all schools around the world. Where Korea needs to develop student-centred teaching practices to address negative attitudes to science, South Africa needs to address basic developmental issues such as improving teachers' subject knowledge, developing language skills, and fostering a culture of learning to improve performance. Therefore, what should be ascertained from the research is 'what is the best for one' and 'what is the best for the other'.

On the other hand, although societal values and conditions differ in Korea and South Africa, from a perspective of teaching and learning theory, it was valuable to find that the key factor such as time was important even in two extremely different countries. However, other key factors such as opportunity to learn and quality still could develop into a further study.

Some researchers found that nations that educate their populations in scientific and technical skills experience improved economic performance (Schofer et al., 2000; Murray, 2008). Although science education by itself is not sufficient condition of high economic development, scientific literacy cannot be separated from the national future development. In this vein, this study is poised to make valuable contributions to Korean and South African science education by examining differences between the two countries as well as the relationships between science achievement and background characteristics.

> *"Major transitions in life are often made mentally and emotionally before they are made physically. Persons facing such changes will usually make the mental adjustments before the physical ones are forced upon them. …Emotionally they saw themselves as part of the new, but they were physically located in the old. Yet each in its own way created circles of the new that existed within the old: small islands in a vast ocean. However, the circles expanded and new ones appeared, and together they constituted a powerful force.*
> *It has become possible for yesterday's distant dreams to become tomorrow's reality*." (Rogan & Gray, 1999, p384)

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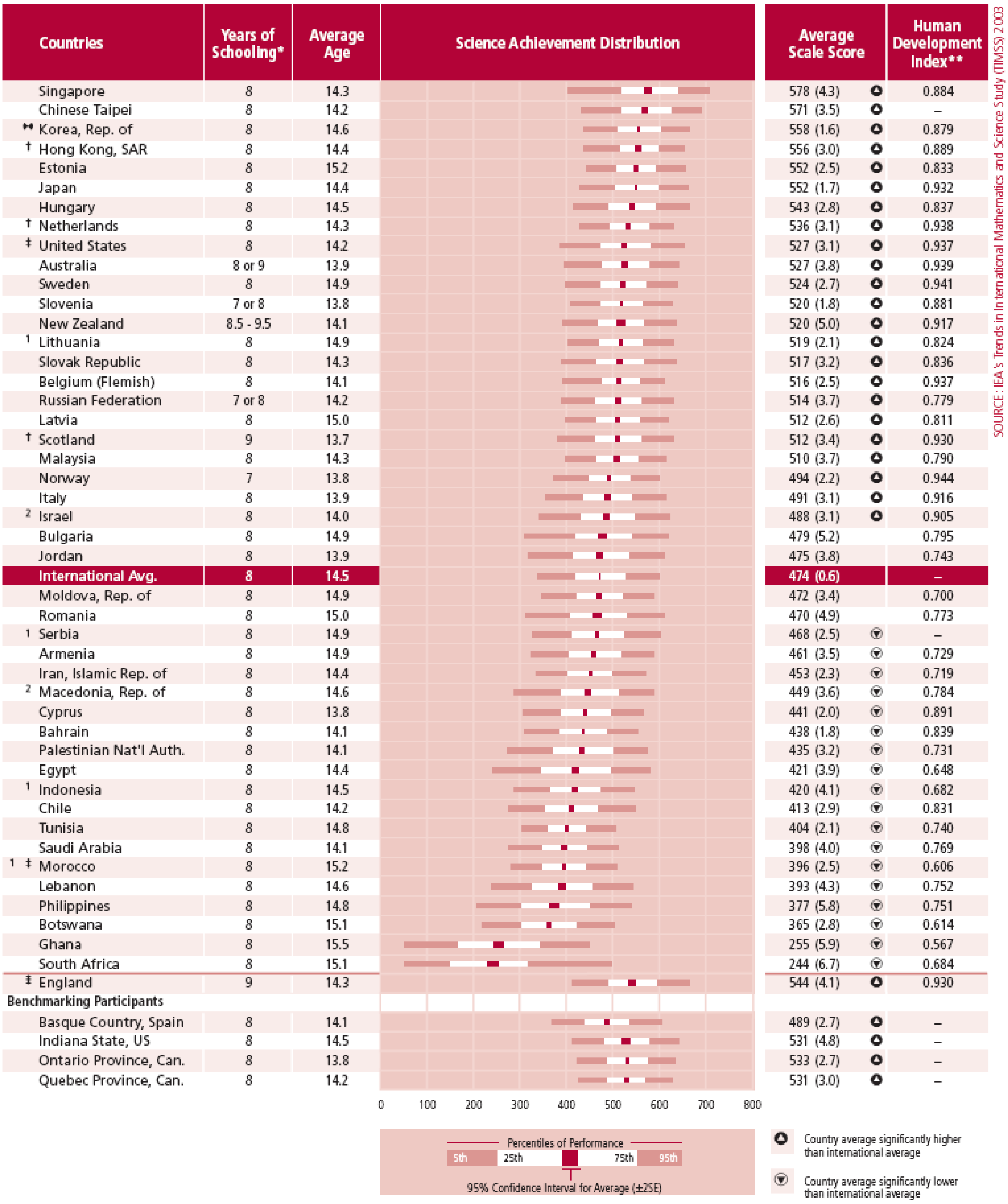
APPENDIX

Appendix A: Distribution of science achievement (Martin, Mullis, Gonzalez & Chrostowski, 2004)



	Countries	Years of Schooling*	Average Age	Science Achievement Distribution	Average Scale Score		Human Development Index**
	Singapore	8	14.3		578 (4.3)	▲	0.884
	Chinese Taipei	8	14.2		571 (3.5)	▲	–
↔	Korea, Rep. of	8	14.6		558 (1.6)	▲	0.879
†	Hong Kong, SAR	8	14.4		556 (3.0)	▲	0.889
	Estonia	8	15.2		552 (2.5)	▲	0.833
	Japan	8	14.4		552 (1.7)	▲	0.932
	Hungary	8	14.5		543 (2.8)	▲	0.837
†	Netherlands	8	14.3		536 (3.1)	▲	0.938
‡	United States	8	14.2		527 (3.1)	▲	0.937
	Australia	8 or 9	13.9		527 (3.8)	▲	0.939
	Sweden	8	14.9		524 (2.7)	▲	0.941
	Slovenia	7 or 8	13.8		520 (1.8)	▲	0.881
	New Zealand	8.5 - 9.5	14.1		520 (5.0)	▲	0.917
1	Lithuania	8	14.9		519 (2.1)	▲	0.824
	Slovak Republic	8	14.3		517 (3.2)	▲	0.836
	Belgium (Flemish)	8	14.1		516 (2.5)	▲	0.937
	Russian Federation	7 or 8	14.2		514 (3.7)	▲	0.779
	Latvia	8	15.0		512 (2.6)	▲	0.811
†	Scotland	9	13.7		512 (3.4)	▲	0.930
	Malaysia	8	14.3		510 (3.7)	▲	0.790
	Norway	7	13.8		494 (2.2)	▲	0.944
	Italy	8	13.9		491 (3.1)	▲	0.916
2	Israel	8	14.0		488 (3.1)	▲	0.905
	Bulgaria	8	14.9		479 (5.2)		0.795
	Jordan	8	13.9		475 (3.8)		0.743
	International Avg.	**8**	**14.5**		**474 (0.6)**		**–**
	Moldova, Rep. of	8	14.9		472 (3.4)		0.700
	Romania	8	15.0		470 (4.9)		0.773
1	Serbia	8	14.9		468 (2.5)	▼	–
	Armenia	8	14.9		461 (3.5)	▼	0.729
	Iran, Islamic Rep. of	8	14.4		453 (2.3)	▼	0.719
2	Macedonia, Rep. of	8	14.6		449 (3.6)	▼	0.784
	Cyprus	8	13.8		441 (2.0)	▼	0.891
	Bahrain	8	14.1		438 (1.8)	▼	0.839
	Palestinian Nat'l Auth.	8	14.1		435 (3.2)	▼	0.731
	Egypt	8	14.4		421 (3.9)	▼	0.648
1	Indonesia	8	14.5		420 (4.1)	▼	0.682
	Chile	8	14.2		413 (2.9)	▼	0.831
	Tunisia	8	14.8		404 (2.1)	▼	0.740
	Saudi Arabia	8	14.1		398 (4.0)	▼	0.769
1 ‡	Morocco	8	15.2		396 (2.5)	▼	0.606
	Lebanon	8	14.6		393 (4.3)	▼	0.752
	Philippines	8	14.8		377 (5.8)	▼	0.751
	Botswana	8	15.1		365 (2.8)	▼	0.614
	Ghana	8	15.5		255 (5.9)	▼	0.567
	South Africa	8	15.1		244 (6.7)	▼	0.684
ǂ	England	9	14.3		544 (4.1)	▲	0.930
Benchmarking Participants							
	Basque Country, Spain	8	14.1		489 (2.7)	▲	–
	Indiana State, US	8	14.5		531 (4.8)	▲	–
	Ontario Province, Can.	8	13.8		533 (2.7)	▲	–
	Quebec Province, Can.	8	14.2		531 (3.0)	▲	–

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

* Represents years of schooling counting from the first year of ISCED Level 1.

** Taken from United Nations Development Programme's *Human Development Report 2003*, p. 237-240.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

ǂ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

↔ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

A dash (–) indicates comparable data are not available.

Appendix B: Student questionnaire in TIMSS (Martin, Mullis, Gonzalez & Chrostowski, 2004)

Question Number	Item Content	Description	Number of items	Analysis
1	Age	Month and year of student's birth	2	
2	Gender	Student's gender	1	
3	Language	Student's frequency of use of the language of the test at home	1	
4	Books in the home	Number of books in the student's home	1	
5	Home possessions	Educational resources and general possessions in the student's home	A-D(4) E-P(12)	RA
6	Parents' education	Highest level of education completed by mother and father	2	
7	Educational expectations	Level of education the student expects to complete	1	
8	Liking mathematics	How much the student likes and feels competent at mathematics	7	NA
9	Valuing mathematics	Importance and value the student attributes to mathematics	5	NA
10	Learning activities in mathematics	Frequency with which student does various learning activities in mathematics lessons	14	NA
11	Liking science	How much the student likes and feels competent at science	7	FA, RA
12	Valuing science	Importance and value the student attributes to science	5	FA, RA
13	Learning activities in science	Frequency with which student does various learning activities in science lessons	14	FA, RA
14	Computers	Whether student uses a computer, where uses it, and frequency with which student uses a computer for various educational activities	A-B(2) C(4)	
15	School climate	Student's affinity for school, and perception of other students' motivation in school and teachers' expectations and care of students	4	FA, RA
16	Safety in school	Whether the student experienced being the object of problematic behaviours by other students	5	RA
17	Out-of-school activities	Frequency with which student does various non-academic activities and homework outside of school	9	FA, RA
18	Extra lessons/ tutoring	Frequency of extra lessons or tutoring in mathematics and science	2	
19	Mathematics homework	Frequency and amount of mathematics homework	2	NA
20	Science homework	Frequency and amount of science homework	2	
21	Persons living in home	Number of people living at home	1	
22	Parents born in country	Whether mother and father were born in country	2	
23	student born in country	Whether student was born in country, and if not age at which student emigrated	2	

Source. Martin et al. (2000)
NA. non applicable due to mathematics-related items, FA. factor analysis, RA. reliability analysis

Appendix C: Science teacher questionnaire in TIMSS (Martin, Mullis, Gonzalez & Chrostowski, 2004)

Question Number	Item Content	Description	Number of items	Analysis
1	Age	Teacher's age	1	
2	Gender	Teacher's gender	1	
3	Teaching experience	Number of years as a teacher	3	
4	Formal education	Highest level of formal education completed by the teacher	1	
5	Teacher training	Number of years of pre-service teacher training completed by the teacher	1	
6	Major area of study	Teacher's major area of study during post-secondary education	9	
7	Teaching requirements	Requirements the teacher had to satisfy in order to become a teacher	5	RA
8	Teaching license	Whether the teacher has a teaching license or certificate, and the type of license	2	
9	Preparation to teach	How ready the teacher feels to teach the topics included in the TIMSS mathematics/science test	A(5), B(5), C(5), D(3), E(3)	FA, RA
10	Teaching load	Number of periods for which the teacher is formally scheduled per week for various activities, and number of minutes in a period	A(1), B(10), C(1),	
11	Extra working time	Number of hours teacher spends on teaching-related activities outside the formal school day	4	
12	Teacher interactions	Frequency of various types of interactions the teacher has with colleagues	4	FA, RA
13	Professional development	Whether the teacher participated in various types of professional development activities	6	RA
14	Attitudes toward subject	Teacher's beliefs about the nature of mathematics/science and how the subject should be taught.	9	FA, RA
15	School setting	Teacher's perceptions about the adequacy of the school facility and about school safety	4	FA, RA
16	School climate	Teacher's perception of teachers' job satisfaction and expectations for student achievement; of parental support and involvement; and of students' regard for school property and desire to do well in school	8	FA, RA
17	Class size	Number of students in the sampled class	1	
18	Time spend teaching subject	Minutes per week the teacher teaches mathematics/science to the sampled class	1	
19	Textbook	Whether a textbook(s) is used as a primary or supplementary resource	2	
20	Student learning	Percentage of time students spend doing various learning activities in a typical week	8	

	activities			
21	Content-related activities	Frequency with which the teacher asks students to do various content-related activities in mathematics/science	11	FA, RA
22	Factors limiting teaching	Extent to which the teacher perceives various student and resource factors to limit teaching	14	FA, RA
23	Emphasis on content areas	Percentage of time spent on mathematics /science content areas over the course of the year	6	
24	Topic coverage	When the students were taught the TIMSS mathematics/ science topics, by content area	A(12), B(8), C(10), D(11), E(3)	FA, RA
25	Computer availability	Whether the students have access to computers during mathematics /science lessons and whether computers have access to Internet	2	
26	Computer use	Frequency with which the students use computers for various learning activities	5	
27	Homework	Whether the teacher assigns mathematics /science homework	1	
28	Frequency of homework	How often the teacher assigns mathematics /science homework	1	
29	Amount of homework	Number of minutes it would take an average student to complete a mathematics/science homework assignment	1	
30	Type of homework	Frequency with which the teacher assigns various types of homework	7	FA, RA
31	Use of homework	How often the teacher uses mathematics /science homework for various purposes	5	FA
32	Assessment	Frequency with which the teacher gives a mathematics/ science test or examination	1	
33	Question format	Item formats the teacher typically uses in mathematics/ science tests or examinations	1	
34	Type of questions	Types of questions the teacher	3	

Source. Martin et al. (2000)
NA. non applicable due to mathematics-related items
FA. factor analysis
RA. reliability analysis

Appendix D: School principal questionnaire in TIMSS (Martin, Mullis, Gonzalez & Chrostowski, 2004)

Question Number	Item Content	Description	Number of items	Analysis
1	Grade levels	Grade range of the school	2	
2	Enrolment	Total school enrolment in all grades and in the target grade	2	
3	Community size	Size of the community in which the school is located	1	
4	Absenteeism	Percentage of students absent from school on a typical school day	1	
5	Stability/ mobility of student body	Percentage of students enrolled at the beginning of the school year who were still enrolled at the time of testing, and percentage of students who enrolled after the beginning of the school year	2	
6	Students' background	Percentage of students who come from economically disadvantaged or affluent homes, and percentage of students whose native language is the language of the test	A(2), B(1)	
7	School climate	Principal's perception of teachers' job satisfaction and expectations for student achievement; of parental support and involvement; and of students' regard for school property and desire to do well in school	8	FA
8	Principal's experience	Number of years as a principal of this school	1	
9	Principal's time allocation	Percentage of time principal spends on various activities across the school year	6	
10	Parental involvement	Whether the school expects parents to participate in various activities	5	
11	Instructional time	Number of days per year and days per week the school is open for instruction, and number of hours of instructional time in a typical day	4	
12	Differentiation of mathematics curriculum	How the school organizes mathematics instruction for students with different levels of ability	1	
13	Tracking in mathematics	Whether the students are grouped by ability in their mathematics classes	1	
14	Enrichment/ remedial mathematics	Whether the school offers enrichment and remedial courses in mathematics	2	
15	Differentiation of science curriculum	How the school organizes science instruction for students with different levels of ability	1	
16	Tracking in science	Whether the students are grouped by ability in their science Classes	1	
17	Enrichment/ remedial science	Whether the school offers enrichment and remedial courses in science	2	
18	Teacher vacancies	Difficulty in filling teacher vacancies in mathematics, science, and computer science/information technology	3	
19	Incentives for	Whether the school uses incentives to	3	

	teachers	recruit or retain teachers in mathematics, science, and/or other subjects		
20	Professional development	Frequency with which teachers participated in various types of professional development activities during the school year	5	FA
21	Teacher evaluation	Whether the school uses various procedures in evaluating mathematics and science teachers	A(4), B(4)	
22	Student behaviour	Frequency and severity of various problematic student behaviours occurring in the school	A(13), B(13)	FA
23	Instructional resources	Degree to which the school's capacity to provide instruction is affected by shortages or inadequacy of various resources	20	FA
24	Computers	Number of computers available for educational purposes, and proportion of computers with access to the Internet	2	
25	Technology support	Whether there is anyone available to help teachers use information and communication technology for teaching and learning, and description of that person	2	

Source. Martin et al. (2000)
NA. non applicable due to mathematics-related items
FA. factor analysis
RA. reliability analysis

Appendix E: Factor analysis of the Korean data

Student questionnaire

Liking science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.868
Bartlett's Test of Sphericity	Approx. Chi-Square	14545.083
	Df	21
	Sig.	.000

Communalities

	Initial	Extraction
do well in science	1.000	.670
take more science	1.000	.470
enjoy learning science	1.000	.586
learn science quickly	1.000	.602
science is more difficult	1.000	.555
not understand a new topic	1.000	.357
science is not strengths	1.000	.623

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.864	55.202	55.202	3.864	55.202	55.202
2	.967	13.821	69.023			
3	.589	8.412	77.435			
4	.495	7.066	84.502			
5	.421	6.012	90.513			
6	.336	4.799	95.312			
7	.328	4.688	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
do well in science	.819
take more science	.686
enjoy learning science	.766
learn science quickly	.776
science is more difficult	.745
not understand a new topic	.597
science is not strengths	.789

Extraction Method: Principal Component Analysis.
[a]. 1 components extracted.

Valuing science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.757
Bartlett's Test of Sphericity	Approx. Chi-Square	8949.398
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
for daily life	1.000	.467
for other subjects	1.000	.523
for university	1.000	.658
for science job	1.000	.547
for job I want	1.000	.671

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.867	57.331	57.331	2.867	57.331	57.331
2	.913	18.261	75.592			
3	.528	10.568	86.160			
4	.413	8.261	94.421			
5	.279	5.579	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
for daily life	.684
for other subjects	.723
for university	.811
for science job	.740
for job I want	.819

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Leaning activities in science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.854
Bartlett's Test of Sphericity	Approx. Chi-Square	18646.543
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
listen to lecture stu	1.000	.659
work problem stu	1.000	.547
watch demonstration stu	1.000	.364
formulate hypothesis stu	1.000	.505
design experiment stu	1.000	.598
conduct experiment stu	1.000	.668
work in small group stu	1.000	.678
write explanation stu	1.000	.639
technology on society stu	1.000	.492
relate to daily life stu	1.000	.514
present work stu	1.000	.485
review homework stu	1.000	.428
have quiz	1.000	.234
begin homework	1.000	.368

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.519	32.282	32.282	4.519	32.282	32.282	3.077	21.982	21.982
2	1.397	9.980	42.262	1.397	9.980	42.262	2.642	18.874	40.855
3	1.261	9.007	51.269	1.261	9.007	51.269	1.458	10.413	51.269
4	.994	7.101	58.370						
5	.836	5.974	64.344						
6	.817	5.839	70.183						
7	.760	5.429	75.612						
8	.690	4.931	80.543						
9	.544	3.884	84.427						
10	.522	3.728	88.155						
11	.512	3.658	91.813						
12	.488	3.486	95.299						
13	.350	2.498	97.797						
14	.308	2.203	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
listen to lecture stu	.107	.247	.766
work problem stu	.110	.437	.587
watch demonstration stu	.576	.178	-.011
formulate hypothesis stu	.514	.468	-.149
design experiment stu	.657	.397	-.089
conduct experiment stu	.792	.199	.026
work in small group stu	.783	-.007	.255
write explanation stu	.736	.119	.288
technology on society stu	.175	.679	.006
relate to daily life stu	.088	.687	.185
present work stu	.401	.569	-.005
review homework stu	.147	.569	.287
have quiz	.148	.458	.042
begin homework	.003	.371	-.479

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.734	.640	.226
2	-.658	.588	.471
3	-.168	.494	-.853

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.729
Bartlett's Test of Sphericity	Approx. Chi-Square	3366.058
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
like being in school	1.000	.478
stu do the best	1.000	.534
tch care about stu	1.000	.630
tch want stu to do best	1.000	.481

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.123	53.073	53.073	2.123	53.073	53.073
2	.751	18.764	71.837			
3	.615	15.386	87.223			
4	.511	12.777	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
like being in school	.691
stu do the best	.731
tch care about stu	.794
tch want stu to do best	.694

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Out-of-school activities

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.664
Bartlett's Test of Sphericity	Approx. Chi-Square	4228.751
	df	36
	Sig.	.000

Communalities

	Initial	Extraction
work paid job	1.000	.687
do jobs at home	1.000	.499
play sports	1.000	.445
read book for enjoy	1.000	.442
do homework	1.000	.599
watch tv or video	1.000	.498
play computer game	1.000	.570
play with friend	1.000	.343
use internet	1.000	.573

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.126	23.620	23.620	2.126	23.620	23.620	1.993	22.140	22.140
2	1.504	16.708	40.328	1.504	16.708	40.328	1.449	16.102	38.242
3	1.027	11.410	51.738	1.027	11.410	51.738	1.215	13.496	51.738
4	.892	9.915	61.652						
5	.842	9.351	71.003						
6	.756	8.402	79.405						
7	.733	8.142	87.547						
8	.642	7.137	94.685						
9	.478	5.315	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
work paid job	-.012	-.066	.826
do jobs at home	.362	.556	.242
play sports	.144	.283	.587
read book for enjoy	-.129	.613	.224
do homework	-.028	.759	-.147
watch tv or video	.705	.019	-.038
play computer game	.673	-.259	.225
play with friend	.555	.187	-.005
use internet	.753	-.039	.071

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 4 iterations.

Component Transformation Matrix

Component	1	2	3
1	.916	.186	.357
2	-.306	.898	.317
3	-.261	-.399	.879

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Computers

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.626
Bartlett's Test of Sphericity	Approx. Chi-Square	3286.214
	df	3
	Sig.	.000

Communalities

	Initial	Extraction
look up ideas for science	1.000	.481
write reports	1.000	.693
analyze data	1.000	.748

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.922	64.060	64.060	1.922	64.060	64.060
2	.699	23.295	87.355			
3	.379	12.645	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
look up ideas for science	.694
write reports	.832
analyze data	.865

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Science teacher questionnaire

Preparation to teach

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.894
Bartlett's Test of Sphericity	Approx. Chi-Square	2366.434
	df	210
	Sig.	.000

Communalities

	Initial	Extraction
ready for biology a	1.000	.786
ready for biology b	1.000	.744
ready for biology c	1.000	.777
ready for biology d	1.000	.717
ready for biology e	1.000	.662
ready for chemistry a	1.000	.883
ready for chemistry b	1.000	.809
ready for chemistry c	1.000	.854
ready for chemistry d	1.000	.761
ready for chemistry e	1.000	.824
ready for physics a	1.000	.818
ready for physics b	1.000	.830
ready for physics c	1.000	.674
ready for physics d	1.000	.757
ready for physics e	1.000	.818
ready for earth science a	1.000	.884
ready for earth science b	1.000	.894
ready for earth science c	1.000	.699
ready for environment a	1.000	.778
ready for environment b	1.000	.879
ready for environment c	1.000	.854

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.555	45.502	45.502	9.555	45.502	45.502	4.241	20.195	20.195
2	3.352	15.960	61.462	3.352	15.960	61.462	3.932	18.724	38.920
3	1.488	7.085	68.548	1.488	7.085	68.548	3.331	15.862	54.782
4	1.229	5.853	74.400	1.229	5.853	74.400	3.036	14.459	69.240
5	1.074	5.116	79.517	1.074	5.116	79.517	2.158	10.276	79.517
6	.605	2.879	82.396						
7	.592	2.817	85.212						
8	.436	2.074	87.287						
9	.364	1.735	89.021						
10	.347	1.651	90.672						
11	.279	1.330	92.002						
12	.257	1.225	93.227						
13	.239	1.140	94.368						
14	.212	1.010	95.378						
15	.200	.953	96.331						
16	.187	.889	97.220						
17	.155	.737	97.957						
18	.129	.616	98.573						
19	.114	.542	99.115						
20	.101	.482	99.597						
21	.085	.403	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
ready for biology a	.109	-.051	.847	.231	.029
ready for biology b	.168	.075	.831	.022	.141
ready for biology c	.099	.157	.811	.275	.092
ready for biology d	.190	.126	.662	.472	.055
ready for biology e	.003	.202	.629	.473	.037
ready for chemistry a	.861	.338	.124	.044	.104
ready for chemistry b	.785	.405	.090	.106	.096
ready for chemistry c	.842	.231	.154	.195	.172
ready for chemistry d	.782	.115	.123	.256	.234
ready for chemistry e	.808	.361	.128	.041	.149
ready for physics a	.339	.817	.147	.039	.111
ready for physics b	.329	.830	.048	.114	.132
ready for physics c	.081	.731	.010	.329	.156
ready for physics d	.402	.706	.117	.003	.288
ready for physics e	.359	.787	.132	.075	.217
ready for earth science a	.254	.248	.080	.105	.861
ready for earth science b	.170	.246	.116	.256	.852
ready for earth science c	.376	.441	.216	.191	.529
ready for environment a	.154	.090	.270	.810	.128
ready for environment b	.163	.143	.302	.841	.184
ready for environment c	.132	.122	.259	.858	.135

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 6 iterations.

Component Transformation Matrix

Component	1	2	3	4	5
1	.562	.530	.382	.380	.336
2	-.369	-.399	.639	.538	-.089
3	-.614	.360	-.373	.366	.469
4	-.404	.609	.441	-.403	-.332
5	-.091	-.244	.336	-.519	.741

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Teacher interaction

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.526
Bartlett's Test of Sphericity	Approx. Chi-Square	90.622
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
interact pedagogy	1.000	.767
interact materials	1.000	.790
interact by visiting	1.000	.757
interact by observing	1.000	.740

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.753	43.831	43.831	1.753	43.831	43.831	1.542	38.555	38.555
2	1.301	32.529	76.360	1.301	32.529	76.360	1.512	37.805	76.360
3	.501	12.535	88.896						
4	.444	11.104	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
interact pedagogy	.855	.191
interact materials	.887	-.052
interact by visiting	-.024	.870
interact by observing	.153	.846

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.730	.683
2	-.683	.730

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Attitudes toward science subject

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.625
Bartlett's Test of Sphericity	Approx. Chi-Square	113.699
	df	36
	Sig.	.000

Communalities

	Initial	Extraction
more than 1 representation	1.000	.611
solving by hypothesis	1.000	.605
learning by memorizing	1.000	.577
scientific investigation	1.000	.513
getting correct answer	1.000	.482
scientific theories	1.000	.325
skill and knowledge	1.000	.632
modelling phenomena	1.000	.494
scientific discoveries	1.000	.472

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.917	21.303	21.303	1.917	21.303	21.303	1.909	21.208	21.208
2	1.666	18.517	39.820	1.666	18.517	39.820	1.537	17.079	38.287
3	1.127	12.527	52.347	1.127	12.527	52.347	1.265	14.060	52.347
4	.899	9.990	62.337						
5	.857	9.523	71.860						
6	.810	8.999	80.858						
7	.625	6.946	87.804						
8	.562	6.242	94.046						
9	.536	5.954	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
more than 1 representation	.654	.045	.425
solving by hypothesis	.775	.033	-.052
learning by memorizing	.052	.254	.714
scientific investigation	.673	.121	-.212
getting correct answer	-.090	.677	-.128
scientific theories	.541	-.172	-.057
skill and knowledge	-.180	.712	.304
modelling phenomena	.240	.660	.025
scientific discoveries	-.183	-.156	.644

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.992	.117	-.040
2	-.081	.860	.504
3	.094	-.496	.863

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School setting

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.676
Bartlett's Test of Sphericity	Approx. Chi-Square	71.905
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
school facility repair	1.000	.385
safe neighbourhood	1.000	.525
feel safe at school	1.000	.656
security policy of school	1.000	.380

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.946	48.650	48.650	1.946	48.650	48.650
2	.808	20.191	68.841			
3	.752	18.796	87.637			
4	.495	12.363	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
school facility repair	.620
safe neighbourhood	.725
feel safe at school	.810
security policy of school	.616

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.774
Bartlett's Test of Sphericity	Approx. Chi-Square	451.453
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
teacher job satisfaction	1.000	.535
Teacher understanding curriculum	1.000	.708
teacher success in curriculum	1.000	.691
teacher expectation for student	1.000	.543
parent support for student	1.000	.750
parent involvement in school	1.000	.725
student regard for school	1.000	.552
student desire to do well	1.000	.666

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.702	46.281	46.281	3.702	46.281	46.281	3.094	38.674	38.674
2	1.468	18.348	64.629	1.468	18.348	64.629	2.076	25.955	64.629
3	.669	8.364	72.993						
4	.653	8.161	81.154						
5	.593	7.413	88.567						
6	.402	5.027	93.594						
7	.341	4.260	97.853						
8	.172	2.147	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
teacher job satisfaction	.463	.424
teacher success in curr	.352	.745
Teacher understanding curriculum	.569	.607
teacher expectation for student	.702	.012
parent support for student	.795	-.292
parent involvement in school	.773	-.316
student regard for school	.710	-.149
student desire to do well	.692	-.332

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
teacher job satisfaction	.207	.702
teacher understanding curriculum	.194	.819
teacher success in curriculum	.047	.830
teacher expectation for student	.635	.374
parent support for student	.856	.133
parent involvement in school	.840	.140
student regard for school	.712	.213
student desire to do well	.815	.038

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.853	.522
2	-.522	.853

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Content-related activities

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.769
Bartlett's Test of Sphericity	Approx. Chi-Square	515.303
	df	55
	Sig.	.000

Communalities

	Initial	Extraction
watch demonstration	1.000	.498
formulate hypotheses	1.000	.721
design experiment	1.000	.602
conduct experiment	1.000	.722
work in small group	1.000	.757
write explanation	1.000	.576
put event in order	1.000	.551
technology on society	1.000	.540
learn nature and inquiry	1.000	.753
present work	1.000	.456
relate to daily life	1.000	.549

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.069	36.988	36.988	4.069	36.988	36.988	2.463	22.395	22.395
2	1.649	14.989	51.977	1.649	14.989	51.977	2.217	20.153	42.548
3	1.006	9.148	61.125	1.006	9.148	61.125	2.043	18.576	61.125
4	.932	8.476	69.600						
5	.741	6.732	76.333						
6	.720	6.541	82.874						
7	.556	5.056	87.930						
8	.460	4.180	92.110						
9	.353	3.210	95.320						
10	.283	2.570	97.891						
11	.232	2.109	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
watch demonstration	-.004	.209	.674
formulate hypotheses	.382	-.142	.745
design experiment	.228	.409	.618
conduct experiment	-.046	.611	.589
work in small group	-.082	.758	.419
write explanation	.313	.686	.081
put event in order	.579	.416	.205
technology on society	.727	.090	-.056
learn nature and inquiry	.817	.167	.239
relate to daily life	.661	.038	.135
present work	.436	.596	-.053

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 14 iterations.

Component Transformation Matrix

Component	1	2	3
1	.582	.606	.542
2	.809	-.363	-.462
3	.084	-.708	.702

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factors limiting teaching

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.811
Bartlett's Test of Sphericity	Approx. Chi-Square	775.730
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
limit in academic difference	1.000	.491
limit in background	1.000	.346
limit in special need	1.000	.361
limit in hardware	1.000	.790
limit in software	1.000	.741
limit in using computer	1.000	.663
limit in other equipment	1.000	.772
limit in equipment	1.000	.637
limit in physical facility	1.000	.685
limit in stu/tch ratio	1.000	.456
limit in uninterest	1.000	.742
limit in low morale	1.000	.714
limit disruptive student	1.000	.504
limit in textbook	1.000	.299

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.725	33.753	33.753	4.725	33.753	33.753	3.515	25.108	25.108
2	2.153	15.378	49.130	2.153	15.378	49.130	2.356	16.828	41.936
3	1.324	9.459	58.589	1.324	9.459	58.589	2.331	16.653	58.589
4	.933	6.666	65.256						
5	.803	5.737	70.992						
6	.778	5.560	76.552						
7	.760	5.428	81.980						
8	.624	4.458	86.439						
9	.493	3.518	89.957						
10	.402	2.868	92.825						
11	.327	2.333	95.158						
12	.273	1.952	97.110						
13	.236	1.683	98.793						
14	.169	1.207	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
limit in academic difference	.662	.049	.224
limit in background	.557	.164	.089
limit in special need	.550	.189	-.150
limit in uninterest	.881	.006	.121
limit in low morale	.855	.046	.086
limit disruptive student	.799	.093	.131
limit in hardware	-.002	.054	.877
limit in software	.169	.217	.749
limit in using computer	.128	.246	.780
limit in textbook	-.104	.667	-.020
limit in other equipment	.206	.815	.188
limit in equipment	.221	.773	.260
limit in physical facility	.224	.611	.283
limit in stu/tch ratio	.347	.299	.299

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 4 iterations.

Component Transformation Matrix

Component	1	2	3
1	.728	.490	.480
2	-.686	.508	.521
3	-.012	.708	-.706

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Topic coverage

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.836
Bartlett's Test of Sphericity	Approx. Chi-Square	5644.273
	df	946
	Sig.	.000

Communalities

	Initial	Extraction		Initial	Extraction
OTL biology a	1.000	.608	OTL biology b	1.000	.640
OTL biology f	1.000	.482	OTL biology c	1.000	.584
OTL biology g	1.000	.654	OTL biology d	1.000	.698
OTL biology h	1.000	.670	OTL biology e	1.000	.784
OTL biology i	1.000	.726	OTL chemistry a	1.000	.649
OTL biology j	1.000	.585	OTL chemistry b	1.000	.675
OTL biology k	1.000	.672	OTL physics a	1.000	.589
OTL biology l	1.000	.652	OTL physics b	1.000	.668
OTL chemistry c	1.000	.576	OTL physics d	1.000	.683
OTL chemistry d	1.000	.532	OTL physics e	1.000	.788
OTL chemistry e	1.000	.599	OTL physics f	1.000	.686
OTL chemistry f	1.000	.625	OTL physics g	1.000	.729
OTL chemistry g	1.000	.736	OTL physics i	1.000	.558
OTL chemistry h	1.000	.611	OTL physics j	1.000	.473
OTL physics c	1.000	.566	OTL earth science a	1.000	.827
OTL physics h	1.000	.411	OTL earth science b	1.000	.690
OTL earth science d	1.000	.647	OTL earth science c	1.000	.714
OTL earth science f	1.000	.495	OTL earth science e	1.000	.737
OTL earth science i	1.000	.614	OTL earth science g	1.000	.679
OTL environment a	1.000	.802	OTL earth science h	1.000	.542
OTL environment b	1.000	.814	OTL earth science j	1.000	.687
OTL environment c	1.000	.725	OTL earth science k	1.000	.696

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.075	20.624	20.624	9.075	20.624	20.624	4.338	9.860	9.860
2	4.925	11.194	31.818	4.925	11.194	31.818	4.329	9.838	19.698
3	3.215	7.307	39.125	3.215	7.307	39.125	4.056	9.219	28.917
4	2.502	5.687	44.812	2.502	5.687	44.812	2.896	6.582	35.499
5	2.068	4.701	49.513	2.068	4.701	49.513	2.705	6.147	41.646
6	1.735	3.942	53.455	1.735	3.942	53.455	2.663	6.051	47.697
7	1.406	3.196	56.651	1.406	3.196	56.651	2.429	5.520	53.217
8	1.373	3.120	59.772	1.373	3.120	59.772	1.742	3.959	57.176
9	1.208	2.745	62.517	1.208	2.745	62.517	1.741	3.956	61.132
10	1.070	2.432	64.948	1.070	2.432	64.948	1.679	3.816	64.948
11	.927	2.107	67.055						
12	.874	1.986	69.041						
13	.810	1.842	70.883						

14	.774	1.760	72.643						
15	.769	1.748	74.391						
16	.756	1.719	76.110						
17	.677	1.539	77.649						
18	.642	1.459	79.109						
19	.606	1.376	80.485						
20	.588	1.335	81.820						
21	.574	1.304	83.125						
22	.553	1.256	84.381						
23	.526	1.195	85.576						
24	.485	1.101	86.677						
25	.469	1.066	87.743						
26	.444	1.009	88.753						
27	.432	.981	89.733						
28	.419	.953	90.687						
29	.389	.885	91.572						
30	.373	.848	92.420						
31	.354	.805	93.224						
32	.353	.803	94.027						
33	.305	.694	94.721						
34	.300	.682	95.403						
35	.285	.649	96.051						
36	.260	.591	96.642						
37	.245	.557	97.199						
38	.220	.501	97.700						
39	.213	.484	98.184						
40	.200	.454	98.638						
41	.182	.414	99.052						
42	.161	.365	99.417						
43	.157	.356	99.774						
44	.100	.226	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component									
	1	2	3	4	5	6	7	8	9	10
OTL biology a	.362	.307	.203	-.002	.158	-.039	-.001	.125	.318	-.446
OTL biology f	.432	.374	.094	.124	.114	-.204	-.110	.014	.191	-.169
OTL biology g	.331	.278	.178	.165	.196	-.069	-.317	-.188	-.301	.374
OTL biology h	.354	.525	.121	.133	-.090	-.053	-.420	.091	-.161	.123
OTL biology i	.401	.572	.052	.132	-.231	-.244	-.287	.054	-.123	.064
OTL biology j	.425	.465	.142	.198	-.034	-.270	-.192	.087	.005	-.102
OTL biology k	.363	.284	.265	.253	.220	-.007	.062	.489	-.182	.026
OTL biology l	.332	.274	.349	.262	.225	.064	.054	.430	-.178	-.049
OTL chemistry c	.448	.212	-.335	-.099	.153	.091	-.152	.248	.191	-.235

OTL chemistry d	.486	.243	-.234	.028	.214	-.122	.052	.060	.336	-.040
OTL chemistry e	.444	.379	-.365	-.057	.214	.209	.073	-.122	.079	.074
OTL chemistry f	.494	.283	-.393	-.235	.229	.174	.011	-.056	-.009	-.075
OTL chemistry g	.514	.319	-.347	-.114	.312	.297	.079	-.128	.053	.161
OTL chemistry h	.421	.218	-.213	-.058	.264	.261	.207	.240	-.107	.295
OTL physics c	.563	.164	-.082	-.114	.008	.095	-.189	-.174	-.335	-.118
OTL physics h	.411	.219	-.274	.045	.198	.203	.143	.081	.091	.044
OTL earth science d	.518	.153	-.169	-.351	-.046	-.085	-.269	-.323	.107	-.082
OTL earth science f	.492	.258	-.187	-.224	-.024	.065	-.079	-.244	.118	.129
OTL earth science i	.437	.117	-.157	.033	-.398	.449	-.010	.023	-.147	-.038
OTL environment a	.395	.541	-.043	.077	-.339	-.301	.341	-.094	.029	.120
OTL environment b	.383	.473	-.029	.109	-.431	-.266	.380	-.115	.025	.124
OTL environment c	.338	.469	-.048	.120	-.286	-.247	.481	-.027	-.007	-.007
OTL biology b	.303	.009	.615	.006	.214	.176	.191	-.167	.143	-.092
OTL biology c	.273	-.001	.573	.248	-.063	.240	.005	-.178	.156	.040
OTL biology d	.346	.050	.696	-.034	.125	.147	.014	-.210	.073	.061
OTL biology e	.286	.059	.658	.275	.116	.258	.037	-.276	.157	.092
OTL chemistry a	.426	-.479	-.297	.303	.081	-.205	.034	-.060	-.066	-.022
OTL chemistry b	.454	-.461	-.260	.364	.140	-.148	.004	-.121	.024	.015
OTL physics a	.494	-.267	.035	.093	.115	-.161	.193	-.112	-.291	-.300
OTL physics b	.572	-.472	-.115	.248	.097	-.123	-.038	-.080	-.100	-.014
OTL physics d	.588	-.187	.036	-.137	.014	.081	.064	-.046	-.421	-.303
OTL physics e	.522	-.446	.173	-.421	.077	-.135	.104	.201	.057	.175
OTL physics f	.496	-.399	.151	-.339	.115	.011	.157	.193	-.015	.259
OTL physics g	.450	-.481	-.271	.390	.130	-.142	.033	-.081	.128	.092
OTL physics i	.383	-.382	-.129	.366	.271	-.107	-.011	-.151	-.047	.071
OTL physics j	.503	-.311	.073	.198	.033	.038	.190	-.033	-.127	-.150
OTL earth science a	.603	-.345	.175	-.448	-.120	-.243	-.007	.134	.019	.147
OTL earth science b	.633	-.150	.099	-.410	-.221	.036	-.041	-.093	-.083	-.149
OTL earth science c	.679	-.198	.185	-.361	-.186	-.021	-.080	.012	.028	-.081
OTL earth science e	.588	-.366	.237	-.336	-.117	-.160	-.041	.168	.081	.106
OTL earth science g	.514	-.387	-.061	.278	-.215	-.058	-.253	-.010	.247	.099
OTL earth science h	.369	-.288	-.049	.237	-.207	.044	-.234	.307	.262	.047
OTL earth science j	.370	-.162	-.146	.180	-.491	.457	.020	.128	.042	.031
OTL earth science k	.337	-.253	-.087	.315	-.484	.409	.002	.070	.000	-.069

Extraction Method: Principal Component Analysis.

[a]. 10 components extracted.

Rotated Component Matrix[a]

	Component									
	1	2	3	4	5	6	7	8	9	10
OTL biology a	.062	-.058	.176	.253	.046	.107	-.036	.681	.131	.105
OTL biology f	.028	.098	.208	.170	.328	.230	-.086	.475	.079	.015
OTL biology g	.005	.135	.199	.252	.668	.015	-.149	-.230	.101	.035
OTL biology h	-.011	-.112	.158	.072	.746	.127	.113	.132	.156	.007

OTL biology i	.015	-.073	.109	-.018	.710	.381	.092	.204	.086	.031
OTL biology j	.009	.048	.088	.103	.535	.311	-.019	.385	.171	.051
OTL biology k	.072	.039	.127	.154	.268	.110	.010	.166	.716	.046
OTL biology l	.028	.003	.089	.254	.239	.061	.028	.187	.687	.101
OTL chemistry c	.118	.064	.499	-.195	.109	-.053	.142	.475	.088	.049
OTL chemistry d	.106	.223	.487	-.004	.078	.212	-.066	.403	.038	-.123
OTL chemistry e	-.045	.056	.738	.009	.116	.151	.041	.085	-.032	.050
OTL chemistry f	.105	.030	.716	-.108	.097	.045	.022	.161	-.046	.219
OTL chemistry g	.037	.083	.840	.071	.100	.066	.028	2.455E-5	-.001	.055
OTL chemistry h	.148	.039	.639	-.014	.039	.080	.070	-.147	.379	-.017
OTL physics c	.165	.096	.352	.047	.394	.034	.129	.032	-.060	.474
OTL physics h	.003	.128	.577	.009	-.002	.111	.109	.113	.159	.003
OTL earth science d	.314	.046	.384	.004	.318	.076	.003	.232	-.450	.188
OTL earth science f	.211	.015	.517	.073	.245	.183	.072	.066	-.271	.036
OTL earth science i	.066	-.035	.297	.026	.135	.135	.653	-.046	-.002	.235
OTL environment a	.042	-.039	.198	.029	.233	.835	.039	.080	.009	.002
OTL environment b	.044	-.017	.137	.048	.184	.860	.124	.033	-.017	.009
OTL environment c	-.018	-.019	.166	.020	.054	.812	.046	.104	.116	.091
OTL biology b	.175	-.007	.043	.737	-.083	.023	-.079	.138	.119	.132
OTL biology c	.049	.063	-.089	.712	.106	.046	.209	.051	.051	-.025
OTL biology d	.259	-.054	.002	.768	.150	.007	-.053	.037	.060	.091
OTL biology e	-.002	.081	-.004	.866	.124	.024	.066	.016	.077	-.026
OTL chemistry a	.137	.766	.044	-.134	-.035	.019	.081	5.866E-5	-.006	.123
OTL chemistry b	.094	.803	.099	-.017	-.018	-.013	.083	.021	-.031	.054
OTL physics a	.204	.464	.017	.095	-.041	.122	-.036	.088	.103	.535
OTL physics b	.262	.730	.067	.048	.067	-.037	.121	.009	.021	.196
OTL physics d	.339	.229	.154	.070	.064	.003	.155	.036	.096	.670
OTL physics e	.838	.214	.085	.076	-.114	-.047	-.044	-.014	.091	.029
OTL physics f	.729	.201	.172	.124	-.124	-.061	.011	-.144	.169	.025
OTL physics g	.113	.826	.113	-.007	-.060	.006	.108	.020	-.020	-.075
OTL physics i	.035	.720	.106	.101	.036	-.078	-.034	-.053	.042	.063
OTL physics j	.199	.467	.049	.208	-.089	.082	.179	.043	.148	.315
OTL earth science a	.879	.174	.024	.030	.077	.082	.023	.035	-.031	.084
OTL earth science b	.612	.044	.158	.113	.104	.085	.228	.121	-.191	.393
OTL earth science c	.697	.106	.113	.165	.130	.062	.215	.185	-.110	.251
OTL earth science e	.811	.198	-.017	.115	.063	.022	.104	.094	.016	.041
OTL earth science g	.283	.580	-.033	.083	.183	-.014	.389	.147	-.137	-.174
OTL earth science h	.250	.359	-.049	-.030	.107	-.091	.449	.230	.100	-.251
OTL earth science j	.108	.137	.121	.030	-.037	.077	.794	-.050	.014	.012
OTL earth science k	.025	.251	-.019	.080	-.042	.050	.783	-.022	.010	.083

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 8 iterations.

Type of homework

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.597
Bartlett's Test of Sphericity	Approx. Chi-Square	94.208
	df	21
	Sig.	.000

Communalities

	Initial	Extraction
homework on problem	1.000	.630
homework on application	1.000	.618
homework on textbook	1.000	.574
homework on definition	1.000	.607
homework on project	1.000	.782
homework on investigation	1.000	.712
homework on report	1.000	.405

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.977	28.238	28.238	1.977	28.238	28.238	1.718	24.536	24.536
2	1.312	18.739	46.977	1.312	18.739	46.977	1.547	22.105	46.641
3	1.040	14.858	61.835	1.040	14.858	61.835	1.064	15.194	61.835
4	.830	11.858	73.693						
5	.765	10.930	84.623						
6	.587	8.382	93.005						
7	.490	6.995	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
homework on problem	.781	-.139	.025
homework on application	.528	.298	-.501
homework on textbook	.729	.091	.184
homework on definition	.468	.595	-.182
homework on project	.196	.219	.834
homework on investigation	-.182	.824	.012
homework on report	.076	.591	.222

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 7 iterations.

Component Transformation Matrix

Component	1	2	3
1	.787	.616	.039
2	-.599	.748	.285
3	.147	-.248	.958

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Use of homework

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.534
Bartlett's Test of Sphericity	Approx. Chi-Square	46.521
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
homework monitor	1.000	.587
homework feedback	1.000	.534
homework correct	1.000	.696
homework discussion	1.000	.233
homework grade	1.000	.732

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.608	32.164	32.164	1.608	32.164	32.164	1.606	32.115	32.115
2	1.174	23.487	55.651	1.174	23.487	55.651	1.177	23.535	55.651
3	.984	19.683	75.333						
4	.640	12.802	88.136						
5	.593	11.864	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
homework monitor	.757	-.121
homework feedback	.714	.158
homework correct	.429	-.715
homework discussion	.483	-.008
homework grade	.326	.791

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.997	-.075
2	.075	.997

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School principal questionnaire

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.852
Bartlett's Test of Sphericity	Approx. Chi-Square	633.309
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
teacher job satisfaction-p	1.000	.483
teacher understand goals	1.000	.597
teacher degree of success	1.000	.653
teacher expect student	1.000	.658
parent support student	1.000	.589
parent involve school	1.000	.574
student regard school	1.000	.499
student desire do well	1.000	.649

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.701	58.764	58.764	4.701	58.764	58.764
2	.970	12.130	70.894			
3	.762	9.525	80.418			
4	.455	5.689	86.108			
5	.354	4.428	90.535			
6	.319	3.987	94.523			
7	.271	3.388	97.910			
8	.167	2.090	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
teacher job satisfaction-p	.695
teacher understand goals	.773
teacher degree of success	.808
teacher expect student	.811
parent support student	.768
parent involve school	.758
student regard school	.706
student desire do well	.805

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Professional development

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.719
Bartlett's Test of Sphericity	Approx. Chi-Square	143.690
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
develop curriculum	1.000	.490
develop school goal	1.000	.257
develop content knowledge	1.000	.660
develop teaching skill	1.000	.576
develop ICT	1.000	.402

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.385	47.695	47.695	2.385	47.695	47.695
2	.973	19.457	67.153			
3	.660	13.206	80.359			
4	.634	12.679	93.037			
5	.348	6.963	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
develop curriculum	.700
develop school goal	.507
develop content knowledge	.812
develop teaching skill	.759
develop ICT	.634

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Student behaviour (frequencies)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.858
Bartlett's Test of Sphericity	Approx. Chi-Square	590.925
	df	78
	Sig.	.000

Communalities

	Initial	Extraction
frequency of late arrival	1.000	.761
frequency of absenteeism	1.000	.552
frequency of skipping	1.000	.535
frequency of dress code	1.000	.635
frequency of disturbance	1.000	.582
frequency of profanity	1.000	.609
frequency of vandalism	1.000	.579
frequency of theft	1.000	.548
frequency of intimidating student	1.000	.675
frequency of injury to student	1.000	.572
frequency of cheating	1.000	.420
frequency of intimidating teacher	1.000	.602
frequency of injury to teacher	1.000	.494

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.872	37.474	37.474	4.872	37.474	37.474	3.137	24.134	24.134
2	1.565	12.039	49.513	1.565	12.039	49.513	2.900	22.311	46.445
3	1.124	8.649	58.161	1.124	8.649	58.161	1.523	11.716	58.161
4	.855	6.576	64.738						
5	.783	6.025	70.762						
6	.647	4.977	75.740						
7	.628	4.832	80.572						
8	.588	4.524	85.096						
9	.525	4.040	89.136						
10	.450	3.459	92.595						
11	.347	2.667	95.262						
12	.338	2.602	97.864						
13	.278	2.136	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
frequency of late arrival	.849	.162	-.122
frequency of absenteeism	.667	.272	-.181
frequency of skipping	.661	.141	.280
frequency of dress code	.764	.221	.041
frequency of disturbance	.695	.310	.050
frequency of profanity	.184	.757	.041
frequency of vandalism	.223	.726	-.042
frequency of theft	.250	.665	.208
frequency of intimidating student	.183	.799	.053
frequency of injury to student	.308	.588	.362
frequency of cheating	.420	.274	.410
frequency of intimidating teacher	.054	.177	.753
frequency of injury to teacher	-.120	-.043	.691

Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.709	.678	.192
2	-.539	.345	.769
3	.455	-.649	.610

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Student behaviour (severity)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.914
Bartlett's Test of Sphericity	Approx. Chi-Square	1116.074
	df	78
	Sig.	.000

Communalities

	Initial	Extraction
severity of late arrival	1.000	.629
severity of absenteeism	1.000	.472
severity of skipping	1.000	.599
severity of dress code	1.000	.581
severity of disturbance	1.000	.673
severity of cheating	1.000	.628
severity of profanity	1.000	.632
severity of vandalism	1.000	.636
severity of theft	1.000	.652
severity of intimidating student	1.000	.701
severity of injury to student	1.000	.688
severity of intimidating teacher	1.000	.817
severity of injury to teacher	1.000	.790

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.950	53.461	53.461	6.950	53.461	53.461	5.425	41.731	41.731
2	1.550	11.920	65.380	1.550	11.920	65.380	3.074	23.649	65.380
3	.843	6.484	71.864						
4	.700	5.388	77.252						
5	.527	4.053	81.305						
6	.400	3.077	84.382						
7	.383	2.943	87.326						
8	.362	2.783	90.108						
9	.322	2.474	92.583						
10	.291	2.238	94.821						
11	.288	2.213	97.034						
12	.206	1.583	98.617						
13	.180	1.383	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
severity of late arrival	.760	.229
severity of absenteeism	.667	.162
severity of skipping	.767	.106
severity of dress code	.762	-.012
severity of disturbance	.807	.144
severity of cheating	.493	.621
severity of profanity	.695	.386
severity of vandalism	.710	.364
severity of theft	.633	.501
severity of intimidating student	.719	.428
severity of injury to student	.633	.536
severity of intimidating teacher	.180	.886
severity of injury to teacher	.004	.889

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.847	.531
2	-.531	.847

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Instructional resources

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.865
Bartlett's Test of Sphericity	Approx. Chi-Square	1569.906
	df	171
	Sig.	.000

Communalities

	Initial	Extraction
shortage of building and ground	1.000	.679
shortage of heat/cool and light	1.000	.652
shortage of space	1.000	.666
shortage for handicapped	1.000	.362
shortage of computer for math	1.000	.639
shortage of software for math	1.000	.634
shortage of calculator for math	1.000	.758
shortage of library for math	1.000	.648
shortage of AV for math	1.000	.599
shortage of lab equipment	1.000	.652
shortage of computer for science	1.000	.804
shortage of software for science	1.000	.822
shortage of calculator for science	1.000	.551
shortage of library for science	1.000	.719
shortage of AV for science	1.000	.775
shortage of teacher	1.000	.727
shortage of computer staff	1.000	.576
shortage of material	1.000	.704
shortage of budget	1.000	.716

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.875	41.447	41.447	7.875	41.447	41.447	4.287	22.564	22.564
2	1.884	9.914	51.361	1.884	9.914	51.361	4.056	21.348	43.912
3	1.697	8.931	60.292	1.697	8.931	60.292	2.223	11.698	55.610
4	1.228	6.463	66.756	1.228	6.463	66.756	2.118	11.146	66.756
5	.976	5.136	71.892						
6	.744	3.916	75.808						
7	.699	3.679	79.488						
8	.662	3.484	82.972						
9	.489	2.572	85.543						
10	.468	2.461	88.004						
11	.415	2.182	90.186						
12	.358	1.887	92.073						
13	.321	1.689	93.762						
14	.285	1.498	95.261						
15	.261	1.373	96.633						
16	.214	1.126	97.760						

17	.181	.951	98.710						
18	.150	.787	99.497						
19	.095	.503	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
shortage of building and ground	.053	.163	.746	.305
shortage of heat/cool and light	.222	.133	.754	.128
shortage of space	.155	.193	.768	.121
shortage for handicapped	.107	.558	.189	-.062
shortage of computer for math	.298	.697	.246	-.066
shortage of software for math	.208	.701	.315	-.011
shortage of calculator for math	.002	.825	.044	.275
shortage of library for math	.336	.668	.054	.294
shortage of AV for math	.468	.578	.186	.111
shortage of lab equipment	.758	.130	.244	.034
shortage of computer for science	.787	.380	.144	-.141
shortage of software for science	.783	.442	.100	-.063
shortage of calculator for science	.230	.658	.002	.254
shortage of library for science	.602	.532	-.015	.270
shortage of AV for science	.785	.299	.176	.194
shortage of teacher	.685	-.011	.031	.507
shortage of computer staff	.626	.084	.113	.406
shortage of material	.191	.111	.229	.776
shortage of budget	.016	.207	.292	.766

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 7 iterations.

Component Transformation Matrix

Component	1	2	3	4
1	.645	.619	.334	.299
2	-.403	-.221	.618	.638
3	-.634	.725	.103	-.249
4	.141	-.206	.705	-.664

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix F: Factor analysis of the South African data

Student questionnaire

Liking science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.701
Bartlett's Test of Sphericity	Approx. Chi-Square	6811.325
	df	21
	Sig.	.000

Communalities

	Initial	Extraction
do well in science	1.000	.554
take more science	1.000	.596
enjoy learning science	1.000	.337
learn science quickly	1.000	.612
science is more difficult	1.000	.593
not understand a new topic	1.000	.563
science is not strengths	1.000	.515

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.160	30.856	30.856	2.160	30.856	30.856	2.094	29.908	29.908
2	1.610	23.006	53.863	1.610	23.006	53.863	1.677	23.955	53.863
3	.810	11.565	65.428						
4	.703	10.042	75.470						
5	.631	9.016	84.486						
6	.585	8.352	92.838						
7	.501	7.162	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
do well in science	.741	.067
take more science	.772	.024
enjoy learning science	.580	-.023
learn science quickly	.779	.072
science is more difficult	.022	.770
not understand a new topic	.002	.750
science is not strengths	.070	.714

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.938	.348
2	-.348	.938

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Valuing science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.812
Bartlett's Test of Sphericity	Approx. Chi-Square	8929.328
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
for daily life	1.000	.550
for other subjects	1.000	.549
for university	1.000	.623
for science job	1.000	.270
for job I want	1.000	.680

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.671	53.425	53.425	2.671	53.425	53.425
2	.838	16.756	70.181			
3	.549	10.982	81.163			
4	.532	10.637	91.801			
5	.410	8.199	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
for daily life	.742
for other subjects	.741
for university	.789
for science job	.519
for job I want	.824

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Leaning activities in science

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.894
Bartlett's Test of Sphericity	Approx. Chi-Square	13498.830
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
watch demonstration stu	1.000	.393
formulate hypothesis stu	1.000	.487
design experiment stu	1.000	.478
conduct experiment stu	1.000	.481
work in small group stu	1.000	.319
write explanation stu	1.000	.315
technology on society stu	1.000	.303
relate to daily life stu	1.000	.363
work problem stu	1.000	.519
begin homework	1.000	.637
have quiz	1.000	.281
present work stu	1.000	.436
review homework stu	1.000	.466
listen to lecture stu	1.000	.452

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.747	26.765	26.765	3.747	26.765	26.765	2.597	18.551	18.551
2	1.163	8.304	35.069	1.163	8.304	35.069	2.045	14.609	33.160
3	1.022	7.300	42.369	1.022	7.300	42.369	1.289	9.209	42.369
4	.864	6.170	48.539						
5	.848	6.056	54.595						
6	.814	5.817	60.412						
7	.762	5.440	65.852						
8	.746	5.327	71.179						
9	.726	5.189	76.368						
10	.722	5.155	81.523						
11	.711	5.080	86.603						
12	.682	4.874	91.477						
13	.615	4.393	95.870						
14	.578	4.130	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
watch demonstration stu	.623	.068	.020
formulate hypothesis stu	.684	.049	.130
design experiment stu	.662	.183	.077
conduct experiment stu	.668	.145	.116
work in small group stu	.443	.350	.019
write explanation stu	.500	.254	.007
technology on society stu	.385	.362	.155
relate to daily life stu	.355	.481	-.076
work problem stu	.142	.087	.701
begin homework	.040	.108	.790
have quiz	.281	.420	.163
present work stu	.158	.629	.124
review homework stu	.075	.631	.249
listen to lecture stu	.059	.668	-.054

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.749	.606	.267
2	-.572	.388	.723
3	.335	-.694	.637

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	8240.428
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
like being in school	1.000	.556
stu do the best	1.000	.622
tch care about stu	1.000	.677
tch want stu to do best	1.000	.660

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.516	62.891	62.891	2.516	62.891	62.891
2	.574	14.342	77.233			
3	.498	12.440	89.673			
4	.413	10.327	100.000			

Component Matrix[a]

	Component
	1
like being in school	.746
stu do the best	.788
tch care about stu	.823
tch want stu to do best	.813

[a]. 1 components extracted.

Out-of-school activities

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.728
Bartlett's Test of Sphericity	Approx. Chi-Square	7089.483
	df	36
	Sig.	.000

Communalities

	Initial	Extraction
watch tv or video	1.000	.789
play computer game	1.000	.644
work paid job	1.000	.531
use internet	1.000	.571
play with friend	1.000	.486
do jobs at home	1.000	.519
play sports	1.000	.352
read book for enjoy	1.000	.466
do homework	1.000	.557

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.352	26.128	26.128	2.352	26.128	26.128	2.254	25.042	25.042
2	1.533	17.028	43.156	1.533	17.028	43.156	1.531	17.006	42.048
3	1.031	11.459	54.615	1.031	11.459	54.615	1.131	12.567	54.615
4	.819	9.103	63.719						
5	.768	8.532	72.250						
6	.673	7.476	79.726						
7	.657	7.296	87.022						
8	.614	6.817	93.839						
9	.554	6.161	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
watch tv or video	.398	.038	.793
play computer game	-.028	.716	.361
work paid job	.156	.626	-.339
use internet	.138	.733	-.121
play with friend	.654	-.130	.204
do jobs at home	.676	-.149	-.200
play sports	.571	.160	-.024
read book for enjoy	.647	.022	-.217
do homework	.721	-.157	-.112

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
watch tv or video	.179	-.039	.869
play computer game	-.218	.647	.422
work paid job	.145	.683	-.210
use internet	.058	.753	.007
play with friend	.594	-.089	.354
do jobs at home	.718	-.045	-.030
play sports	.530	.221	.148
read book for enjoy	.671	.123	-.034
do homework	.741	-.060	.066

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.958	.106	.265
2	-.142	.983	.117
3	-.248	-.150	.957

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Science teacher questionnaire

Preparation to teach

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.883
Bartlett's Test of Sphericity	Approx. Chi-Square	3114.162
	df	210
	Sig.	.000

Communalities

	Initial	Extraction
ready for biology a	1.000	.862
ready for biology b	1.000	.789
ready for biology c	1.000	.804
ready for biology e	1.000	.661
ready for chemistry a	1.000	.569
ready for physics d	1.000	.500
ready for biology d	1.000	.592
ready for chemistry b	1.000	.653
ready for chemistry c	1.000	.653
ready for chemistry d	1.000	.594
ready for chemistry e	1.000	.695
ready for physics a	1.000	.714
ready for physics b	1.000	.674
ready for physics c	1.000	.720
ready for physics e	1.000	.621
ready for earth science a	1.000	.717
ready for earth science b	1.000	.748
ready for earth science c	1.000	.721
ready for environment a	1.000	.679
ready for environment b	1.000	.619
ready for environment c	1.000	.761

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.627	36.320	36.320	7.627	36.320	36.320	6.262	29.817	29.817
2	4.405	20.974	57.294	4.405	20.974	57.294	4.428	21.086	50.903
3	2.315	11.025	68.319	2.315	11.025	68.319	3.657	17.416	68.319
4	.877	4.175	72.494						
5	.781	3.720	76.214						
6	.713	3.395	79.608						
7	.522	2.486	82.095						
8	.461	2.197	84.292						
9	.404	1.924	86.215						
10	.363	1.728	87.943						
11	.343	1.635	89.578						
12	.323	1.538	91.116						
13	.303	1.443	92.559						
14	.276	1.314	93.873						
15	.234	1.113	94.986						
16	.221	1.051	96.037						
17	.205	.976	97.013						
18	.201	.958	97.971						
19	.166	.790	98.761						
20	.158	.751	99.513						
21	.102	.487	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
ready for biology a	.437	.498	.650
ready for biology b	.479	.516	.542
ready for biology c	.460	.480	.602
ready for biology e	.486	.523	.389
ready for chemistry a	.658	-.300	.215
ready for physics d	.537	-.406	.215
ready for biology d	.564	.473	.223
ready for chemistry b	.693	-.414	.035
ready for chemistry c	.730	-.346	-.014
ready for chemistry d	.657	-.403	-.023
ready for chemistry e	.719	-.421	-.002
ready for physics a	.684	-.495	-.014
ready for physics b	.705	-.419	-.029
ready for physics c	.694	-.488	-.024
ready for physics e	.583	-.530	-.013
ready for earth science a	.542	.519	-.393
ready for earth science b	.532	.506	-.458
ready for earth science c	.586	.375	-.487
ready for environment a	.617	.434	-.332
ready for environment b	.511	.522	-.292
ready for environment c	.639	.460	-.377

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
ready for biology a	.049	.089	.923
ready for biology b	.063	.191	.865
ready for biology c	.076	.122	.885
ready for biology e	.054	.296	.755
ready for chemistry a	.707	.039	.260
ready for physics d	.684	-.083	.158
ready for biology d	.137	.416	.632
ready for chemistry b	.797	.110	.076
ready for chemistry c	.778	.199	.089
ready for chemistry d	.759	.134	.024
ready for chemistry e	.819	.144	.054
ready for physics a	.840	.092	-.007
ready for physics b	.806	.154	.029
ready for physics c	.842	.107	-.007
ready for physics e	.785	.018	-.063
ready for earth science a	.053	.826	.178
ready for earth science b	.050	.856	.117
ready for earth science c	.175	.830	.047
ready for environment a	.168	.779	.208
ready for environment b	.034	.747	.244
ready for environment c	.166	.834	.196

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Pattern Matrix[a]

	Component		
	1	2	3
ready for biology a	-.011	-.087	.957
ready for biology b	-.004	.031	.878
ready for biology c	.014	-.048	.910
ready for biology e	-.018	.165	.744
ready for chemistry a	.704	-.076	.228
ready for physics d	.699	-.184	.143
ready for biology d	.061	.308	.588
ready for chemistry b	.799	.026	.017
ready for chemistry c	.770	.120	.016
ready for chemistry d	.761	.065	-.041
ready for chemistry e	.820	.064	-.014
ready for physics a	.849	.018	-.071
ready for physics b	.806	.081	-.041
ready for physics c	.850	.034	-.073
ready for physics e	.804	-.044	-.114
ready for earth science a	-.042	.840	.041
ready for earth science b	-.045	.883	-.028
ready for earth science c	.089	.857	-.104
ready for environment a	.079	.773	.075
ready for environment b	-.058	.745	.126
ready for environment c	.072	.833	.053

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

[a]. Rotation converged in 6 iterations.

Component Correlation Matrix

Component	1	2	3
1	1.000	.221	.160
2	.221	1.000	.351
3	.160	.351	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Teacher interaction

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.516
Bartlett's Test of Sphericity	Approx. Chi-Square	133.761
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
develop pedagogy	1.000	.716
develop materials	1.000	.714
develop by visiting	1.000	.796
develop by observing	1.000	.797

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.789	44.730	44.730	1.789	44.730	44.730	1.591	39.776	39.776
2	1.234	30.847	75.577	1.234	30.847	75.577	1.432	35.801	75.577
3	.591	14.786	90.363						
4	.385	9.637	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
develop pedagogy	.546	.647
develop materials	.580	.614
develop by visiting	.774	-.443
develop by observing	.745	-.491

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
develop pedagogy	.051	.845
develop materials	.098	.839
develop by visiting	.886	.107
develop by observing	.891	.051

Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.802	.597
2	-.597	.802

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Attitudes toward science subject

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.797
Bartlett's Test of Sphericity	Approx. Chi-Square	362.930
	df	36
	Sig.	.000

Communalities

	Initial	Extraction
more than 1 representation	1.000	.590
solving by hypothesis	1.000	.598
learning by memorizing	1.000	.617
scientific investigation	1.000	.593
getting correct answer	1.000	.800
scientific theories	1.000	.488
skill and knowledge	1.000	.503
modelling phenomena	1.000	.590
scientific discoveries	1.000	.681

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.097	34.416	34.416	3.097	34.416	34.416	2.969	32.984	32.984
2	1.313	14.592	49.008	1.313	14.592	49.008	1.393	15.483	48.467
3	1.050	11.665	60.673	1.050	11.665	60.673	1.098	12.205	60.673
4	.786	8.737	69.410						
5	.702	7.796	77.206						
6	.612	6.801	84.007						
7	.586	6.511	90.518						
8	.463	5.143	95.660						
9	.391	4.340	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
more than 1 representation	.738	-.083	.197
solving by hypothesis	.724	-.170	.213
learning by memorizing	.282	.724	.113
scientific investigation	.678	-.362	.055
getting correct answer	.070	.383	.805
scientific theories	.609	.102	-.326
skill and knowledge	.700	.061	-.099
modelling phenomena	.760	-.072	-.084
scientific discoveries	.219	.675	-.421

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
more than 1 representation	.746	.041	.179
solving by hypothesis	.756	-.044	.157
learning by memorizing	.092	.662	.413
scientific investigation	.750	-.160	-.068
getting correct answer	.023	.025	.894
scientific theories	.538	.383	-.228
skill and knowledge	.651	.278	-.033
modelling phenomena	.745	.172	-.072
scientific discoveries	.008	.820	-.097

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.964	.264	.046
2	-.259	.874	.411
3	.068	-.407	.911

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School setting

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.745
Bartlett's Test of Sphericity	Approx. Chi-Square	307.946
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
school facility repair	1.000	.256
safe neighbourhood	1.000	.743
feel safe at school	1.000	.807
security policy of school	1.000	.713

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.519	62.981	62.981	2.519	62.981	62.981
2	.834	20.860	83.841			
3	.404	10.098	93.938			
4	.242	6.062	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
school facility repair	.506
safe neighbourhood	.862
feel safe at school	.898
security policy of school	.844

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin `Measure of Sampling Adequacy.		.806
Bartlett's Test of Sphericity	Approx. Chi-Square	640.342
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
teacher job satisfaction	1.000	.439
teacher success in curr	1.000	.765
teacher understanding curriculum	1.000	.677
teacher expectation for student	1.000	.518
parent support for student	1.000	.649
parent involvement in school	1.000	.742
student regard for school	1.000	.731
student desire to do well	1.000	.617

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.804	47.556	47.556	3.804	47.556	47.556	2.733	34.159	34.159
2	1.334	16.669	64.225	1.334	16.669	64.225	2.405	30.066	64.225
3	.729	9.114	73.339						
4	.656	8.205	81.543						
5	.582	7.270	88.813						
6	.333	4.167	92.980						
7	.316	3.946	96.926						
8	.246	3.074	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
teacher job satisfaction	.630	.206
teacher success in curr	.705	.518
teacher understanding curriculum	.668	.481
teacher expectation for student	.545	.471
parent support for student	.776	-.215
parent involvement in school	.749	-.425
student regard for school	.734	-.439
student desire to do well	.683	-.388

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
teacher job satisfaction	.338	.570
teacher success in curr	.190	.854
teacher understanding curriculum	.186	.802
teacher expectation for student	.100	.713
parent support for student	.726	.349
parent involvement in school	.844	.173
student regard for school	.841	.153
student desire to do well	.770	.157

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.752	.659
2	-.659	.752

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Content-related activities

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.781
Bartlett's Test of Sphericity	Approx. Chi-Square	506.998
	df	55
	Sig.	.000

Communalities

	Initial	Extraction
watch demonstration	1.000	.622
formulate hypotheses	1.000	.396
design experiment	1.000	.566
conduct experiment	1.000	.638
work in small group	1.000	.642
write explanation	1.000	.751
put event in order	1.000	.485
technology on society	1.000	.588
learn nature and inquiry	1.000	.635
present work	1.000	.346
relate to daily life	1.000	.477

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.618	32.891	32.891	3.618	32.891	32.891	2.259	20.532	20.532
2	1.368	12.439	45.330	1.368	12.439	45.330	2.020	18.365	38.897
3	1.160	10.544	55.874	1.160	10.544	55.874	1.867	16.977	55.874
4	.843	7.667	63.541						
5	.822	7.472	71.013						
6	.727	6.606	77.619						
7	.679	6.169	83.788						
8	.542	4.924	88.712						
9	.520	4.732	93.443						
10	.376	3.422	96.866						
11	.345	3.134	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
watch demonstration	.407	-.006	.675
formulate hypotheses	.492	-.112	.376
design experiment	.617	-.338	.266
conduct experiment	.641	-.423	.220
work in small group	.584	-.418	-.355
write explanation	.634	-.326	-.492
put event in order	.647	.094	-.239
technology on society	.612	.454	-.088
learn nature and inquiry	.523	.601	-.033
present work	.548	.199	-.081
relate to daily life	.555	.408	.046

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
watch demonstration	.178	-.176	.748
formulate hypotheses	.182	.113	.591
design experiment	.100	.376	.644
conduct experiment	.055	.465	.647
work in small group	.085	.780	.163
write explanation	.202	.841	.053
put event in order	.506	.462	.124
technology on society	.744	.151	.108
learn nature and inquiry	.795	-.014	.057
present work	.507	.251	.162
relate to daily life	.659	.063	.198

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.630	.569	.528
2	.769	-.553	-.321
3	-.109	-.609	.786

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factors limiting teaching

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.804
Bartlett's Test of Sphericity	Approx. Chi-Square	1676.252
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
limit in academic difference	1.000	.746
limit in background	1.000	.774
limit in special need	1.000	.349
limit in hardware	1.000	.915
limit in software	1.000	.931
limit in using computer	1.000	.842
limit in other equipment	1.000	.826
limit in equipment	1.000	.824
limit in physical facility	1.000	.753
limit in stu/tch ratio	1.000	.347
limit in uninterest	1.000	.724
limit in low morale	1.000	.734
limit disruptive student	1.000	.682
limit in textbook	1.000	.490

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.137	36.690	36.690	5.137	36.690	36.690	3.003	21.450	21.450
2	2.341	16.720	53.410	2.341	16.720	53.410	2.854	20.387	41.837
3	1.348	9.628	63.038	1.348	9.628	63.038	2.391	17.077	58.914
4	1.112	7.941	70.979	1.112	7.941	70.979	1.689	12.065	70.979
5	.849	6.064	77.043						
6	.762	5.441	82.484						
7	.641	4.579	87.063						
8	.500	3.571	90.634						
9	.403	2.877	93.510						
10	.271	1.934	95.445						
11	.246	1.761	97.205						
12	.186	1.326	98.531						
13	.149	1.061	99.593						
14	.057	.407	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component			
	1	2	3	4
limit in academic difference	.515	.327	.082	.607
limit in background	.466	.356	.190	.628
limit in special need	.339	.470	.066	.090
limit in hardware	.764	-.256	-.514	.032
limit in software	.788	-.250	-.495	.054
limit in using computer	.771	-.265	-.420	.019
limit in other equipment	.790	-.333	.299	-.032
limit in equipment	.729	-.300	.408	-.192
limit in physical facility	.767	-.261	.274	-.145
limit in stu/tch ratio	.410	.149	.390	-.067
limit in uninterest	.384	.705	-.067	-.275
limit in low morale	.460	.682	-.161	-.176
limit disruptive student	.343	.646	-.090	-.374
limit in textbook	.593	-.137	.305	-.165

[a]. 4 components extracted.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
limit in academic difference	.129	.185	.167	.817
limit in background	.154	.070	.152	.850
limit in special need	.103	.012	.453	.364
limit in hardware	.225	.921	.090	.088
limit in software	.246	.921	.091	.119
limit in using computer	.297	.860	.078	.094
limit in other equipment	.812	.371	-.046	.168
limit in equipment	.876	.233	.016	.042
limit in physical facility	.790	.344	.059	.083
limit in stu/tch ratio	.495	-.084	.235	.201
limit in uninterest	.076	.039	.838	.121
limit in low morale	.044	.166	.814	.205
limit disruptive student	.078	.043	.821	-.002
limit in textbook	.666	.175	.109	.059

Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 6 iterations.

Component Transformation Matrix

Component	1	2	3	4
1	.648	.609	.325	.323
2	-.289	-.322	.831	.349
3	.652	-.722	-.133	.189
4	-.269	.061	-.431	.859

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Topic coverage

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.829
Bartlett's Test of Sphericity	Approx. Chi-Square	3184.262
	df	946
	Sig.	.000

Communalities

	Initial	Extraction		Initial	Extraction
OTL biology a	1.000	.532	OTL biology b	1.000	.638
OTL biology f	1.000	.579	OTL biology c	1.000	.624
OTL biology g	1.000	.573	OTL biology d	1.000	.619
OTL biology h	1.000	.641	OTL biology e	1.000	.613
OTL biology i	1.000	.575	OTL chemistry a	1.000	.652
OTL biology j	1.000	.617	OTL chemistry b	1.000	.607
OTL biology k	1.000	.708	OTL physics a	1.000	.674
OTL biology l	1.000	.626	OTL physics b	1.000	.585
OTL chemistry c	1.000	.624	OTL physics d	1.000	.561
OTL chemistry d	1.000	.606	OTL physics e	1.000	.796
OTL chemistry e	1.000	.435	OTL physics f	1.000	.704
OTL chemistry f	1.000	.634	OTL physics g	1.000	.667
OTL chemistry g	1.000	.645	OTL physics i	1.000	.560
OTL chemistry h	1.000	.619	OTL physics j	1.000	.585
OTL physics c	1.000	.627	OTL earth science a	1.000	.590
OTL physics h	1.000	.625	OTL earth science b	1.000	.619
OTL earth science d	1.000	.617	OTL earth science c	1.000	.620
OTL earth science f	1.000	.574	OTL earth science e	1.000	.566
OTL earth science i	1.000	.646	OTL earth science g	1.000	.506
OTL environment a	1.000	.598	OTL earth science h	1.000	.506
OTL environment b	1.000	.777	OTL earth science j	1.000	.709
OTL environment c	1.000	.695	OTL earth science k	1.000	.689

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.507	21.607	21.607	9.507	21.607	21.607	5.062	11.504	11.504
2	3.378	7.676	29.283	3.378	7.676	29.283	2.815	6.399	17.902
3	2.393	5.438	34.721	2.393	5.438	34.721	2.735	6.217	24.119
4	1.864	4.236	38.958	1.864	4.236	38.958	2.323	5.281	29.400
5	1.702	3.868	42.826	1.702	3.868	42.826	2.215	5.035	34.435
6	1.442	3.277	46.103	1.442	3.277	46.103	2.161	4.910	39.345
7	1.398	3.177	49.280	1.398	3.177	49.280	2.120	4.819	44.164
8	1.250	2.840	52.121	1.250	2.840	52.121	2.061	4.684	48.848
9	1.193	2.712	54.833	1.193	2.712	54.833	1.687	3.834	52.682
10	1.105	2.511	57.344	1.105	2.511	57.344	1.625	3.694	56.377
11	1.027	2.333	59.677	1.027	2.333	59.677	1.283	2.916	59.292
12	1.006	2.287	61.964	1.006	2.287	61.964	1.176	2.672	61.964
13	.970	2.204	64.168						

14	.927	2.107	66.275						
15	.906	2.059	68.334						
16	.892	2.028	70.362						
17	.846	1.923	72.285						
18	.807	1.834	74.119						
19	.742	1.686	75.805						
20	.722	1.640	77.445						
21	.672	1.527	78.972						
22	.664	1.510	80.482						
23	.611	1.389	81.871						
24	.598	1.359	83.230						
25	.575	1.306	84.536						
26	.561	1.274	85.810						
27	.513	1.165	86.975						
28	.490	1.113	88.089						
29	.480	1.091	89.180						
30	.451	1.025	90.204						
31	.434	.986	91.190						
32	.430	.977	92.168						
33	.392	.891	93.058						
34	.373	.847	93.905						
35	.349	.794	94.699						
36	.346	.787	95.487						
37	.326	.742	96.228						
38	.297	.675	96.904						
39	.284	.644	97.548						
40	.263	.597	98.146						
41	.251	.571	98.717						
42	.239	.544	99.261						
43	.169	.384	99.645						
44	.156	.355	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
OTL biology a	.429	.229	.344	-.037	.182	-.051	-.027	.247	-.088	-.203	-.154	.078
OTL biology f	.407	.139	.201	.228	.508	.028	-.091	.093	.124	.005	-.072	.073
OTL biology g	.510	.038	-.008	.322	.235	-.184	-.110	-.061	-.050	.270	.003	.164
OTL biology h	.363	.287	.229	.065	.112	-.051	-.107	-.381	.005	-.119	.362	.230
OTL biology i	.197	.308	.456	-.115	.360	-.062	.119	.071	.056	.039	.215	-.131
OTL biology j	.363	.261	.451	-.102	.112	-.056	-.008	.117	.093	-.393	.093	-.043
OTL biology k	.429	-.052	.051	.335	-.202	.178	-.232	.116	.226	-.273	.160	.339
OTL biology l	.469	-.253	-.026	.282	-.260	.031	-.099	.098	.194	-.048	.337	.142

OTL chemistry c	.369	.389	-.199	-.210	-.324	.084	-.079	.187	-.305	.016	.003	-.080
OTL chemistry d	.425	.396	-.088	.040	-.243	.040	-.322	-.296	.042	.060	-.041	-.031
OTL chemistry e	.443	.074	-.272	-.100	-.066	-.207	-.090	.123	.118	.091	.219	-.091
OTL chemistry f	.410	.299	-.116	.074	-.110	-.511	.123	.115	.201	.032	-.016	-.117
OTL chemistry g	.531	.093	-.021	-.193	-.071	-.316	.111	.004	.293	-.211	-.208	.160
OTL chemistry h	.472	.036	-.088	-.005	-.212	-.472	.132	.153	.234	.137	-.032	-.065
OTL physics c	.445	.191	.166	.182	-.197	.173	-.099	-.117	-.007	-.161	-.001	-.462
OTL physics h	.453	.205	-.347	.024	.250	.120	.136	.052	.172	.321	.068	.146
OTL earth science d	.587	-.251	.171	-.070	-.002	-.129	-.195	-.026	.011	.148	.167	-.265
OTL earth science f	.532	-.333	-.081	-.169	.112	.207	-.029	.033	-.165	-.040	.197	.140
OTL earth science i	.567	-.339	.056	-.200	.157	.218	.206	.133	.110	.125	-.076	-.015
OTL environment a	.461	-.247	.290	.156	-.106	-.068	.349	.029	-.131	.170	.180	.003
OTL environment b	.400	-.078	.464	.196	-.270	.241	.423	-.176	.026	.077	-.093	.027
OTL environment c	.481	-.059	.407	.162	-.302	.153	.299	-.183	.061	.145	.008	-.076
OTL biology b	.520	-.116	.060	.338	-.046	.103	-.378	.035	-.066	-.104	-.250	-.042
OTL biology c	.486	-.264	-.024	.421	-.143	-.101	-.142	.141	-.200	.022	-.088	-.144
OTL biology d	.455	-.101	-.116	.407	.093	.111	.019	.250	-.051	.083	-.342	.109
OTL biology e	.351	.294	.366	.091	.387	.004	-.094	.068	-.169	.235	-.120	-.016
OTL chemistry a	.275	.506	-.129	-.175	-.188	.075	.020	.170	-.312	.142	.156	.246
OTL chemistry b	.416	.503	.162	-.283	-.088	-.093	-.035	.015	-.103	-.049	-.064	.199
OTL physics a	.435	.545	-.074	-.062	-.061	.245	-.019	.314	.036	-.049	-.027	-.112
OTL physics b	.455	.449	.090	-.198	-.240	.131	-.046	-.044	-.075	.158	-.138	-.042
OTL physics d	.484	.211	-.340	.118	.058	.070	.189	-.103	-.002	-.210	.062	-.224
OTL physics e	.547	.167	-.260	.146	.230	-.164	.283	-.263	-.279	-.254	-.037	-.091
OTL physics f	.448	.014	-.413	.103	.220	-.069	.215	-.332	-.194	-.253	-.092	.055
OTL physics g	.294	.347	-.153	-.005	.049	.145	-.192	-.450	.231	.333	-.096	.023
OTL physics i	.376	-.065	-.421	.154	.148	.123	.065	.238	-.056	.046	.236	-.234
OTL physics j	.404	.162	-.390	.092	.068	.271	.201	.045	.321	-.069	.059	.058
OTL earth science a	.522	-.397	-.085	-.105	.010	-.207	-.265	-.052	-.052	-.011	-.139	.068
OTL earth science b	.614	-.353	.129	-.167	-.023	-.083	-.203	-.098	.062	-.044	.060	-.071
OTL earth science c	.589	-.301	.058	-.213	-.133	-.140	.197	-.012	.038	.041	-.201	.119
OTL earth science e	.553	-.272	-.040	-.151	.081	-.185	-.148	-.140	-.239	.103	.108	-.021
OTL earth science g	.527	-.295	.049	-.151	.049	.025	.049	.084	-.268	.012	.164	.065
OTL earth science h	.512	-.189	-.125	-.133	-.253	.083	.096	-.027	-.161	-.080	-.100	.226
OTL earth science j	.538	-.279	.006	-.435	.130	.238	-.147	.016	.205	-.010	-.063	-.101
OTL earth science k	.556	-.292	-.103	-.398	.146	.224	-.008	-.078	.130	-.090	-.112	-.109

Extraction Method: Principal Component Analysis.

[a]. 12 components extracted.

Rotated Component Matrix[a]

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
OTL biology a	.152	.256	.573	.063	.097	.203	.069	-.051	-.123	.067	.042	-.179
OTL biology f	.104	-.105	.615	-.007	.022	.301	.095	.218	.148	.091	-.043	-.017

OTL biology g	.152	.000	.278	.093	.210	.405	.186	.098	.294	.123	-.197	.266
OTL biology h	.062	.114	.395	.120	.004	-.195	.282	-.113	.355	.419	-.018	.148
OTL biology i	.012	.043	.685	.131	.070	-.226	-.038	.057	.005	-.081	.067	.124
OTL biology j	.118	.152	.605	.090	.127	-.115	.064	-.086	-.122	.231	.251	-.184
OTL biology k	.123	.074	.068	.104	.031	.271	-.014	.127	.039	.749	.061	-.119
OTL biology l	.260	-.023	-.089	.216	.198	.174	-.037	.174	-.015	.606	.070	.176
OTL chemistry c	.102	.737	-.061	-.032	.113	.065	.082	.083	.004	-.021	.178	.058
OTL chemistry d	.056	.384	.014	.010	.146	.111	.123	-.025	.553	.186	.256	-.006
OTL chemistry e	.265	.202	-.006	-.118	.425	-.006	.060	.238	.083	.129	.075	.200
OTL chemistry f	-.043	.160	.144	.033	.729	.070	.163	.099	.067	.018	.075	.027
OTL chemistry g	.295	.129	.163	.066	.537	.010	.199	.024	.070	.140	-.048	-.393
OTL chemistry h	.172	.105	.009	.145	.732	.104	.024	.090	.022	.032	.000	.026
OTL physics c	.085	.177	.151	.247	.051	.149	.127	.039	.149	.094	.656	.036
OTL physics h	.144	.168	.124	.021	.162	.093	.142	.598	.289	.000	-.237	.087
OTL earth science d	.564	-.016	.173	.151	.245	.119	-.048	-.024	.110	.069	.247	.302
OTL earth science f	.631	.114	.042	.079	-.137	.067	.158	.180	-.079	.206	-.087	.132
OTL earth science i	.620	-.022	.141	.296	.033	.112	-.018	.346	-.067	-.068	-.054	-.089
OTL environment a	.264	-.004	.128	.599	.163	.105	.081	.022	-.155	.088	-.062	.269
OTL environment b	.101	.037	.114	.842	-.030	.093	.041	.001	.047	.089	.085	-.121
OTL environment c	.171	.068	.100	.760	.092	.071	.004	.009	.131	.109	.174	.010
OTL biology b	.270	.057	.110	.041	-.002	.621	.072	-.040	.146	.248	.265	-.043
OTL biology c	.231	.009	-.047	.172	.178	.602	.123	-.020	-.087	.160	.199	.237
OTL biology d	.119	.041	.077	.149	.063	.681	.116	.279	-.023	.056	-.077	-.078
OTL biology e	.057	.163	.640	.106	-.033	.274	.002	.005	.194	-.169	-.042	.137
OTL chemistry a	-.045	.751	.079	.012	.042	-.044	.074	.116	.057	.076	-.174	.133
OTL chemistry b	.098	.587	.352	.051	.197	-.072	.102	-.102	.169	.059	-.052	-.164
OTL physics a	-.017	.579	.277	-.009	.110	.099	.001	.393	.048	.053	.258	-.120
OTL physics b	.118	.594	.153	.203	.120	.041	-.006	.042	.312	-.069	.159	-.094
OTL physics d	.093	.164	.036	.049	.159	.047	.509	.381	.071	.061	.285	.010
OTL physics e	.140	.125	.168	.090	.166	.126	.807	.129	.042	-.042	.079	.061
OTL physics f	.204	.028	-.029	-.004	.062	.125	.774	.164	.109	.016	-.042	-.046
OTL physics g	.043	.134	.042	.026	.044	.011	.076	.190	.774	-.030	.030	-.027
OTL physics i	.194	.071	-.048	-.086	.084	.177	.202	.537	-.129	.044	.149	.316
OTL physics j	.075	.100	-.017	.051	.109	.023	.224	.644	.134	.203	.036	-.169
OTL earth science a	.627	-.035	-.043	-.066	.214	.303	.116	-.137	.082	.106	-.036	.013
OTL earth science b	.685	-.038	.104	.114	.184	.099	.037	-.081	.098	.188	.157	.055
OTL earth science c	.570	.080	-.013	.336	.314	.129	.111	-.013	-.025	-.005	-.128	-.178
OTL earth science e	.604	.076	.058	.031	.143	.125	.219	-.106	.101	.026	-.032	.290
OTL earth science g	.568	.155	.101	.176	.000	.093	.148	.035	-.167	.096	-.078	.207
OTL earth science h	.447	.296	-.179	.233	.061	.154	.216	.019	-.036	.167	-.100	-.132
OTL earth science j	.753	.031	.117	-.005	-.003	-.025	-.093	.226	.112	-.005	.145	-.182
OTL earth science k	.733	.013	.043	.034	-.010	-.023	.117	.245	.081	-.054	.133	-.216

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 12 iterations.

Type of homework

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.644
Bartlett's Test of Sphericity	Approx. Chi-Square	141.788
	df	21
	Sig.	.000

Communalities

	Initial	Extraction
homework on problem	1.000	.198
homework on application	1.000	.390
homework on textbook	1.000	.650
homework on definition	1.000	.636
homework on project	1.000	.423
homework on investigation	1.000	.627
homework on report	1.000	.443

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.082	29.739	29.739	2.082	29.739	29.739	1.892	27.027	27.027
2	1.285	18.361	48.100	1.285	18.361	48.100	1.475	21.073	48.100
3	.951	13.587	61.687						
4	.824	11.777	73.464						
5	.736	10.514	83.978						
6	.614	8.767	92.746						
7	.508	7.254	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
homework on problem	.439	-.066
homework on application	.623	.050
homework on textbook	.425	.685
homework on definition	.463	.650
homework on project	.529	-.379
homework on investigation	.636	-.471
homework on report	.650	-.145

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
homework on problem	.416	.157
homework on application	.519	.348
homework on textbook	.036	.806
homework on definition	.087	.793
homework on project	.646	-.072
homework on investigation	.785	-.101
homework on report	.638	.191

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.873	.488
2	-.488	.873

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Use of homework

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.548
Bartlett's Test of Sphericity	Approx. Chi-Square	81.773
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
homework monitor	1.000	.704
homework feedback	1.000	.738
homework correct	1.000	.516
homework discussion	1.000	.597
homework grade	1.000	.359

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.682	33.644	33.644	1.682	33.644	33.644	1.490	29.802	29.802
2	1.232	24.637	58.281	1.232	24.637	58.281	1.424	28.479	58.281
3	.855	17.106	75.388						
4	.705	14.102	89.489						
5	.526	10.511	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
homework monitor	.661	-.517
homework feedback	.541	-.668
homework correct	.584	.417
homework discussion	.618	.465
homework grade	.480	.358

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
homework monitor	.661	-.517
homework feedback	.541	-.668
homework correct	.584	.417
homework discussion	.618	.465
homework grade	.480	.358

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
homework monitor	.162	.823
homework feedback	-.027	.859
homework correct	.715	.066
homework discussion	.771	.051
homework grade	.597	.043

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.757	.653
2	.653	-.757

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

School principal questionnaire

School climate

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.834
Bartlett's Test of Sphericity	Approx. Chi-Square	551.338
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
teacher job satisfaction-p	1.000	.500
teacher understand goals	1.000	.629
teacher degree of success	1.000	.718
teacher expect student	1.000	.454
parent support student	1.000	.588
parent involve school	1.000	.543
student regard school	1.000	.692
student desire do well	1.000	.739

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.806	47.580	47.580	3.806	47.580	47.580	2.706	33.820	33.820
2	1.055	13.186	60.766	1.055	13.186	60.766	2.156	26.946	60.766
3	.827	10.336	71.101						
4	.642	8.022	79.124						
5	.593	7.407	86.531						
6	.401	5.008	91.538						
7	.349	4.367	95.905						
8	.328	4.095	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
teacher job satisfaction-p	.644	-.291
teacher understand goals	.703	-.367
teacher degree of success	.718	-.449
teacher expect student	.668	-.088
parent support student	.766	.036
parent involve school	.724	.133
student regard school	.599	.577
student desire do well	.682	.523

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
teacher job satisfaction-p	.683	.182
teacher understand goals	.777	.160
teacher degree of success	.840	.107
teacher expect student	.573	.355
parent support student	.570	.512
parent involve school	.477	.562
student regard school	.099	.826
student desire do well	.198	.837

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.775	.633
2	-.633	.775

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Professional development

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.834
Bartlett's Test of Sphericity	Approx. Chi-Square	590.163
	df	10
	Sig.	.000

Communalities

	Initial	Extraction
develop curriculum	1.000	.600
develop school goal	1.000	.773
develop content knowledge	1.000	.769
develop teaching skill	1.000	.778
develop ICT	1.000	.548

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.467	69.339	69.339	3.467	69.339	69.339
2	.561	11.216	80.555			
3	.520	10.396	90.952			
4	.286	5.719	96.670			
5	.166	3.330	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
develop curriculum	.774
develop school goal	.879
develop content knowledge	.877
develop teaching skill	.882
develop ICT	.740

Extraction Method: Principal Component Analysis.

[a]. 1 components extracted.

Student behaviour (frequencies)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.886
Bartlett's Test of Sphericity	Approx. Chi-Square	1100.199
	df	78
	Sig.	.000

Communalities

	Initial	Extraction
frequency of late arrival	1.000	.667
frequency of absenteeism	1.000	.760
frequency of skipping	1.000	.652
frequency of dress code	1.000	.573
frequency of disturbance	1.000	.547
frequency of profanity	1.000	.646
frequency of vandalism	1.000	.577
frequency of theft	1.000	.656
frequency of intimidating student	1.000	.690
frequency of injury to student	1.000	.523
frequency of cheating	1.000	.444
frequency of intimidating teacher	1.000	.578
frequency of injury to teacher	1.000	.821

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.598	43.062	43.062	5.598	43.062	43.062	4.082	31.398	31.398
2	1.494	11.495	54.557	1.494	11.495	54.557	2.779	21.376	52.774
3	1.041	8.011	62.568	1.041	8.011	62.568	1.273	9.795	62.568
4	.828	6.370	68.938						
5	.721	5.546	74.485						
6	.628	4.834	79.319						
7	.544	4.183	83.502						
8	.479	3.682	87.184						
9	.401	3.087	90.272						
10	.384	2.957	93.228						
11	.346	2.662	95.890						
12	.283	2.178	98.068						
13	.251	1.932	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
frequency of late arrival	.543	-.545	.275
frequency of absenteeism	.583	-.601	.242
frequency of skipping	.738	-.324	.054
frequency of dress code	.710	-.263	.012
frequency of disturbance	.712	-.081	-.183
frequency of profanity	.751	.053	-.282
frequency of vandalism	.705	.252	-.127
frequency of theft	.738	.294	-.157
frequency of intimidating student	.776	.265	-.132
frequency of injury to student	.623	.368	.002
frequency of cheating	.660	-.064	-.064
frequency of intimidating teacher	.576	.383	.316
frequency of injury to teacher	.213	.382	.793

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
frequency of late arrival	.085	.807	.096
frequency of absenteeism	.105	.864	.050
frequency of skipping	.427	.685	.035
frequency of dress code	.448	.610	.020
frequency of disturbance	.607	.416	-.070
frequency of profanity	.737	.307	-.091
frequency of vandalism	.730	.169	.125
frequency of theft	.787	.147	.123
frequency of intimidating student	.795	.198	.139
frequency of injury to student	.665	.068	.275
frequency of cheating	.527	.407	.032
frequency of intimidating teacher	.513	.116	.549
frequency of injury to teacher	.035	.044	.904

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 6 iterations.

Component Transformation Matrix

Component	1	2	3
1	.804	.567	.177
2	.449	-.776	.443
3	-.389	.277	.879

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Student behaviour (severity)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.873
Bartlett's Test of Sphericity	Approx. Chi-Square	1034.315
	df	78
	Sig.	.000

Communalities

	Initial	Extraction
severity of late arrival	1.000	.626
severity of absenteeism	1.000	.661
severity of skipping	1.000	.653
severity of dress code	1.000	.609
severity of disturbance	1.000	.438
severity of cheating	1.000	.551
severity of profanity	1.000	.552
severity of vandalism	1.000	.635
severity of theft	1.000	.655
severity of intimidating student	1.000	.569
severity of injury to student	1.000	.533
severity of intimidating teacher	1.000	.744
severity of injury to teacher	1.000	.783

Extraction Method: Principal Component Analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.439	41.842	41.842	5.439	41.842	41.842	3.230	24.849	24.849
2	1.517	11.668	53.510	1.517	11.668	53.510	2.991	23.009	47.859
3	1.053	8.102	61.612	1.053	8.102	61.612	1.788	13.753	61.612
4	.852	6.556	68.168						
5	.723	5.565	73.733						
6	.621	4.775	78.507						
7	.525	4.037	82.544						
8	.486	3.737	86.281						
9	.435	3.347	89.628						
10	.397	3.051	92.679						
11	.377	2.900	95.578						
12	.293	2.253	97.831						
13	.282	2.169	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
severity of late arrival	.595	-.488	.186
severity of absenteeism	.606	-.536	.088
severity of skipping	.739	-.314	.086
severity of dress code	.625	-.407	.231
severity of disturbance	.634	-.189	.001
severity of cheating	.739	.068	.029
severity of profanity	.672	.207	-.239
severity of vandalism	.620	.049	-.497
severity of theft	.703	.253	-.311
severity of intimidating student	.696	.281	-.070
severity of injury to student	.678	.188	-.197
severity of intimidating teacher	.620	.484	.354
severity of injury to teacher	.418	.479	.616

Extraction Method: Principal Component Analysis.

[a]. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
severity of late arrival	.126	.778	.066
severity of absenteeism	.178	.793	-.029
severity of skipping	.350	.713	.148
severity of dress code	.147	.751	.157
severity of disturbance	.374	.532	.121
severity of cheating	.519	.417	.328
severity of profanity	.690	.199	.191
severity of vandalism	.761	.210	-.108
severity of theft	.772	.165	.176
severity of intimidating student	.626	.206	.365
severity of injury to student	.661	.228	.212
severity of intimidating teacher	.378	.128	.765
severity of injury to teacher	.072	.080	.879

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.695	.621	.363
2	.350	-.733	.583
3	-.628	.278	.727

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Instructional resources

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.918
Bartlett's Test of Sphericity	Approx. Chi-Square	4108.621
	df	171
	Sig.	.000

Communalities

	Initial	Extraction
shortage of building and ground	1.000	.636
shortage of heat/cool and light	1.000	.563
shortage of space	1.000	.621
shortage for handicapped	1.000	.228
shortage of computer for math	1.000	.793
shortage of software for math	1.000	.793
shortage of calculator for math	1.000	.727
shortage of library for math	1.000	.833
shortage of AV for math	1.000	.862
shortage of lab equipment	1.000	.635
shortage of computer for science	1.000	.856
shortage of software for science	1.000	.902
shortage of calculator for science	1.000	.799
shortage of library for science	1.000	.841
shortage of AV for science	1.000	.880
shortage of teacher	1.000	.324
shortage of computer staff	1.000	.765
shortage of material	1.000	.515
shortage of budget	1.000	.544

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.696	56.296	56.296	10.696	56.296	56.296	9.602	50.539	50.539
2	2.423	12.753	69.048	2.423	12.753	69.048	3.517	18.509	69.048
3	.924	4.862	73.910						
4	.824	4.336	78.247						
5	.761	4.006	82.252						
6	.572	3.010	85.262						
7	.452	2.378	87.640						
8	.415	2.185	89.825						
9	.382	2.011	91.835						
10	.329	1.732	93.567						
11	.310	1.634	95.201						
12	.237	1.245	96.446						
13	.182	.957	97.403						
14	.144	.759	98.162						
15	.115	.607	98.769						
16	.093	.490	99.259						
17	.063	.331	99.590						
18	.040	.213	99.803						
19	.037	.197	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
shortage of building and ground	.453	.657
shortage of heat/cool and light	.634	.401
shortage of space	.302	.728
shortage for handicapped	.476	.045
shortage of computer for math	.863	-.220
shortage of software for math	.861	-.228
shortage of calculator for math	.852	.041
shortage of library for math	.897	-.169
shortage of AV for math	.910	-.182
shortage of lab equipment	.785	.136
shortage of computer for science	.888	-.260
shortage of software for science	.899	-.307
shortage of calculator for science	.894	.025
shortage of library for science	.908	-.127

shortage of AV for science	.919	-.191
shortage of teacher	.194	.535
shortage of computer staff	.870	-.091
shortage of material	.442	.565
shortage of budget	.507	.536

Extraction Method: Principal Component Analysis.

[a]. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
shortage of building and ground	.183	.776
shortage of heat/cool and light	.445	.604
shortage of space	.017	.788
shortage for handicapped	.427	.215
shortage of computer for math	.884	.108
shortage of software for math	.885	.101
shortage of calculator for math	.778	.348
shortage of library for math	.897	.168
shortage of AV for math	.914	.161
shortage of lab equipment	.682	.412
shortage of computer for science	.922	.081
shortage of software for science	.949	.040
shortage of calculator for science	.823	.348
shortage of library for science	.892	.212
shortage of AV for science	.925	.156
shortage of teacher	-.014	.569
shortage of computer staff	.844	.231
shortage of material	.206	.687
shortage of budget	.277	.684

Rotation Method: Varimax with Kaiser Normalization.

[a]. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.932	.364
2	-.364	.932

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix G: Reliability analysis of the Korean data

Student questionnaire

Home possession (16 items)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.638	.677	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.768	.146	.994	.849	6.820	.079	16
Item Variances	.105	.006	.250	.244	45.323	.006	16
Inter-Item Correlations	.116	.003	.469	.465	142.891	.004	16

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
calculator at home	11.3238	4.000	.185	.	.632
computer at home	11.3134	3.958	.310	.	.624
desk at home	11.3214	3.953	.265	.	.626
dictionary at home	11.3013	4.078	.184	.	.634
study room at home	11.4955	3.626	.244	.	.625
camera at home	11.3616	3.808	.290	.	.619
car at home	11.4797	3.480	.364	.	.603
audio-com at home	11.4951	3.592	.268	.	.620
VCR at home	11.3934	3.753	.272	.	.620
mobilephone at home	11.3653	3.826	.262	.	.622
printer at home	11.3733	3.757	.311	.	.616
washing machine at home	11.2961	4.101	.192	.	.635
kimchi-refrigerator at home	11.7701	3.395	.283	.	.622
laptop at home	12.1448	3.753	.208	.	.629
airconditioner at home	11.8429	3.332	.320	.	.613
video cam at home	12.0816	3.567	.278	.	.619

Home possession (4 items)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.403	.506	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.788	.446	.977	.532	2.193	.057	4
Item Variances	.125	.022	.247	.225	11.105	.010	4
Inter-Item Correlations	.204	.087	.469	.381	5.382	.017	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
computer at home	2.1739	.619	.312	.231	.346
car at home	2.3402	.429	.257	.071	.294
printer at home	2.2338	.530	.273	.232	.303
air conditioner at home	2.7055	.350	.200	.042	.422

Liking science

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.859	.863	7

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.374	2.168	2.656	.487	1.225	.036	7
Item Variances	.660	.479	.743	.264	1.550	.010	7
Inter-Item Correlations	.473	.233	.657	.425	2.823	.012	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
do well in science	14.3772	13.401	.718	.554	.829
take more science	14.4465	13.252	.565	.459	.849
enjoy learning science	14.2976	12.720	.660	.535	.834
learn science quickly	14.3413	13.306	.668	.470	.834
science is more difficult	13.9930	12.999	.638	.458	.838
not understand a new topic	13.9592	13.816	.481	.299	.860
science is not strengths	14.2744	12.736	.685	.504	.831

Valuing science

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.814	.812	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.522	1.972	2.932	.960	1.487	.124	5
Item Variances	.723	.619	.872	.253	1.409	.012	5
Inter-Item Correlations	.464	.342	.699	.358	2.048	.014	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
for daily life	9.6764	7.498	.518	.370	.801
for other subjects	10.0427	7.328	.565	.404	.788
for university	9.9407	6.564	.671	.528	.756
for science job	10.6364	6.985	.583	.381	.783
for job I want	10.1378	6.294	.680	.573	.753

Learning activities (Practical Learning)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.770	.772	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.652	2.448	2.945	.497	1.203	.046	4
Item Variances	.849	.580	1.044	.464	1.801	.048	4
Inter-Item Correlations	.459	.316	.652	.336	2.061	.015	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
conduct experiment stu	7.66	5.283	.619	.389	.700
work in small group stu	8.05	4.239	.653	.492	.668
WHY write explanation stu	8.16	4.368	.631	.456	.681
watch demonstration stu	7.95	5.566	.413	.204	.790

Learning activities (STS Learning)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.619	.625	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.802	2.678	3.036	.359	1.134	.041	3
Item Variances	.841	.726	.946	.220	1.304	.012	3
Inter-Item Correlations	.357	.281	.495	.214	1.761	.011	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
technology on society stu	5.37	2.325	.479	.265	.455
relate to daily life stu	5.71	2.137	.484	.271	.436
review homework stu	5.73	2.354	.333	.111	.661

Liking school

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.704	.704	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.856	2.639	3.324	.685	1.260	.102	4
Item Variances	.590	.507	.634	.127	1.251	.003	4
Inter-Item Correlations	.373	.279	.452	.173	1.621	.004	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
like being in school	8.6370	3.130	.452	.212	.665
stu do the best	8.7838	3.057	.494	.250	.638
tch care about stu	8.7498	2.845	.566	.328	.591
tch want stu to do best	8.0986	3.324	.450	.228	.665

Safe school

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.596	.631	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.876	.763	.981	.219	1.287	.007	5
Item Variances	.104	.019	.181	.163	9.782	.004	5
Inter-Item Correlations	.255	.142	.370	.228	2.601	.003	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
mine was stolen	3.6155	.601	.316	.102	.585
hit or hurt by other stu	3.4678	.697	.444	.212	.498
made to do things by oth stu	3.4959	.668	.416	.198	.506
made fun of or called names	3.5359	.636	.382	.161	.525
left out of activities	3.3968	.890	.324	.117	.584

Out-of school activities (Play after school)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.636	.637	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.900	1.753	1.989	.236	1.134	.017	3
Item Variances	1.246	1.099	1.483	.384	1.350	.043	3
Inter-Item Correlations	.369	.317	.470	.153	1.484	.006	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
watch tv or video	3.7127	3.783	.371	.138	.635
play computer game	3.9483	2.977	.483	.252	.485
use internet	3.7418	3.469	.492	.254	.478

Computer use

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.717	.715	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.580	1.422	1.732	.309	1.217	.024	3
Item Variances	1.033	.948	1.189	.241	1.254	.018	3
Inter-Item Correlations	.456	.340	.614	.274	1.804	.016	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
look up ideas for science	3.3171	3.464	.421	.182	.758
write reports	3.0078	3.012	.577	.386	.581
analyze data	3.1538	2.560	.627	.424	.508
use internet	3.7418	3.469	.492	.254	.478

Science teacher questionnaire

Preparation to teach (Pchemistry)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.933	.934	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.527	1.369	1.614	.245	1.179	.009	5
Item Variances	.212	.194	.235	.041	1.209	.000	5
Inter-Item Correlations	.740	.556	.857	.301	1.542	.009	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for chemistry a	6.0193	2.696	.894	.828	.905
ready for chemistry b	6.0816	2.720	.826	.767	.917
ready for chemistry c	6.0749	2.709	.864	.754	.910
ready for chemistry d	6.2647	2.821	.693	.539	.943
ready for chemistry e	6.0942	2.665	.847	.729	.913

Preparation to teach (Pphysics)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.913	.915	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.464	1.129	1.627	.497	1.440	.037	5
Item Variances	.232	.198	.259	.060	1.305	.001	5
Inter-Item Correlations	.682	.544	.837	.294	1.540	.013	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for physics a	5.7809	2.763	.828	.744	.883
ready for physics b	5.8018	2.736	.837	.759	.881
ready for physics c	6.1897	3.013	.609	.373	.928
ready for physics d	5.8111	2.723	.785	.648	.892
ready for physics e	5.6925	2.826	.853	.753	.880

Preparation to teach (Pbiology)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.881	.882	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.308	1.163	1.524	.361	1.310	.017	5
Item Variances	.214	.195	.245	.051	1.261	.000	5
Inter-Item Correlations	.599	.432	.707	.275	1.635	.007	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for biology a	5.2636	2.362	.759	.598	.845
ready for biology b	5.0144	2.531	.608	.407	.880
ready for biology c	5.2354	2.353	.792	.636	.838
ready for biology d	5.3753	2.267	.741	.568	.850
ready for biology e	5.2646	2.409	.684	.515	.863

Preparation to teach (Penvironment)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.922	.923	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.190	1.144	1.226	.082	1.072	.002	3
Item Variances	.218	.200	.248	.048	1.243	.001	3
Inter-Item Correlations	.801	.764	.849	.085	1.112	.002	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for environment a	2.3434	.838	.807	.654	.916
ready for environment b	2.4258	.726	.853	.745	.882
ready for environment c	2.3702	.788	.874	.768	.863

Preparation to teach (Pearth science)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.866	.867	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.357	1.265	1.451	.186	1.147	.009	3
Item Variances	.216	.211	.221	.010	1.047	.000	3
Inter-Item Correlations	.684	.603	.821	.218	1.362	.011	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for earth science a	2.6201	.704	.788	.687	.771
ready for earth science b	2.7155	.702	.809	.702	.752
ready for earth science c	2.8064	.779	.645	.418	.902

Professional development

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.800	.800	6

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.374	.255	.524	.268	2.051	.010	6
Item Variances	.151	.130	.161	.031	1.238	.000	6
Inter-Item Correlations	.400	.199	.571	.372	2.871	.009	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
develop content	1.7174	1.962	.534	.399	.774
develop pedagogy/instruction	1.8788	1.865	.625	.424	.752
develop science curriculum	1.8403	1.905	.597	.417	.759
develop IT	1.8198	1.972	.514	.278	.779
develop inquiry skill	1.9640	2.057	.483	.371	.785
develop science assessment	1.9859	1.992	.579	.382	.764

Attitudes towards subject (Inquiry practice)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.602	.601	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.251	3.025	3.440	.414	1.137	.044	3
Item Variances	.204	.174	.234	.059	1.341	.001	3
Inter-Item Correlations	.335	.227	.423	.196	1.862	.008	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
more than 1 representation	6.3127	.579	.349	.133	.590
solving by hypothesis	6.7271	.463	.494	.249	.369
scientific investigation	6.4651	.591	.399	.186	.522

Attitudes towards subject (Knowledge practice)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.489	.485	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.440	1.950	2.848	.898	1.461	.207	3
Item Variances	.180	.158	.206	.048	1.306	.001	3
Inter-Item Correlations	.239	.139	.309	.169	2.217	.006	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
getting correct answer	5.3703	.500	.255	.076	.471
skill and knowledge	4.7984	.380	.383	.147	.244
modelling phenomena	4.4721	.461	.288	.099	.421

School setting (School environment)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.614	.642	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.646	2.236	2.861	.624	1.279	.080	4
Item Variances	.239	.152	.404	.252	2.652	.013	4
Inter-Item Correlations	.310	.207	.471	.264	2.273	.009	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
school facility repair	8.3485	.935	.354	.131	.612
safe neighbourhood	7.7765	1.129	.424	.240	.521
feel safe at school	7.7241	1.168	.538	.320	.466
security policy of school	7.9052	1.273	.334	.144	.584

School climate (High expectation)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.854	.853	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.051	2.612	3.638	1.026	1.393	.141	5
Item Variances	.512	.425	.592	.167	1.392	.005	5
Inter-Item Correlations	.538	.435	.812	.377	1.867	.011	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
teacher expectation for student	11.6195	5.825	.579	.348	.845
parent support for student	12.2648	4.922	.750	.692	.801
parent involvement in school	12.3472	5.020	.735	.679	.805
student regard for school	12.6453	5.505	.602	.396	.841
student desire to do well	12.1515	5.506	.675	.472	.822

School climate (Professional teaching force)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.720	.725	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.410	3.196	3.648	.452	1.141	.052	3
Item Variances	.351	.318	.402	.085	1.267	.002	3
Inter-Item Correlations	.467	.359	.570	.212	1.589	.009	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
teacher job satisfaction	7.0331	1.022	.468	.235	.726
Teacher understand curriculum	6.8442	.999	.629	.407	.527
teacher success in curriculum	6.5809	1.057	.534	.336	.638

Content-related activities (Explanation work)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.687	.703	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.476	1.075	2.045	.970	1.903	.256	3
Item Variances	.372	.208	.520	.312	2.501	.025	3
Inter-Item Correlations	.441	.320	.510	.190	1.594	.009	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
technology on society	3.3536	1.350	.472	.267	.657
learn nature and inquiry	3.1195	.938	.608	.382	.449
relate to daily life	2.3833	.885	.482	.250	.655

Factors limiting teaching (Student resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.831	.830	6

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.303	.753	1.634	.882	2.172	.135	6
Item Variances	.334	.295	.378	.083	1.282	.001	6
Inter-Item Correlations	.448	.233	.804	.571	3.450	.028	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in academic difference	6.4130	4.858	.563	.377	.811
limit in background	6.8825	4.994	.461	.269	.831
limit in special need	7.0679	5.086	.417	.197	.840
limit in uninterest	6.2842	4.312	.783	.708	.765
limit in low morale	6.2684	4.250	.739	.708	.773
limit disruptive student	6.1863	4.507	.667	.553	.789

Factors limiting teaching (Physical resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.796	.801	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.910	.805	1.052	.247	1.307	.016	3
Item Variances	.403	.353	.455	.102	1.289	.003	3
Inter-Item Correlations	.573	.471	.734	.263	1.560	.016	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in other equipment	1.9253	1.185	.719	.575	.637
limit in equipment	1.8567	1.293	.688	.551	.678
limit in physical facility	1.6781	1.304	.529	.283	.846

Factors limiting teaching (Computer resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.792	.792	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.907	.877	.966	.090	1.102	.003	3
Item Variances	.416	.400	.432	.032	1.081	.000	3
Inter-Item Correlations	.560	.532	.590	.057	1.108	.001	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in hardware	1.8454	1.275	.655	.430	.695
limit in software	1.7557	1.347	.611	.374	.742
limit in using computer	1.8427	1.269	.636	.408	.715

Topic coverage (Ophysics)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.811	.821	9

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.739	.423	.900	.477	2.129	.025	9
Item Variances	.115	.060	.169	.110	2.839	.002	9
Inter-Item Correlations	.337	.081	.750	.669	9.296	.018	9

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL physics a	5.8642	2.913	.596	.457	.781
OTL physics b	5.7478	3.088	.646	.530	.782
OTL physics c	6.2249	3.019	.368	.226	.814
OTL physics d	5.9786	2.860	.563	.402	.785
OTL physics e	5.9470	2.752	.631	.632	.775
OTL physics f	6.0366	2.778	.550	.591	.787
OTL physics g	5.7575	3.191	.481	.430	.797
OTL physics i	5.7502	3.287	.385	.332	.806
OTL physics j	5.8736	3.065	.444	.249	.800

Topic coverage (Ochemistry)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.794	.789	8

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.434	.162	.912	.750	5.615	.095	8
Item Variances	.114	.056	.169	.112	2.996	.002	8
Inter-Item Correlations	.319	.073	.731	.658	9.984	.034	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL chemistry a	2.5595	2.700	.305	.467	.796
OTL chemistry b	2.5644	2.687	.312	.474	.795
OTL chemistry c	3.0981	2.210	.503	.323	.773
OTL chemistry d	3.0247	2.221	.502	.287	.773
OTL chemistry e	3.3090	2.285	.611	.547	.754
OTL chemistry f	3.2054	2.191	.609	.534	.752
OTL chemistry g	3.2664	2.123	.732	.696	.732
OTL chemistry h	3.2725	2.460	.435	.260	.780

Topic coverage (Oearth science)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.827	.832	11

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.645	.306	.905	.598	2.954	.034	11
Item Variances	.133	.063	.160	.098	2.558	.001	11
Inter-Item Correlations	.310	.026	.827	.801	31.583	.032	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL earth science a	6.3162	4.896	.566	.	.807
OTL earth science b	6.4283	4.639	.666	.	.796
OTL earth science c	6.3791	4.613	.718	.	.792
OTL earth science d	6.6309	4.961	.432	.	.820
OTL earth science e	6.3277	4.911	.548	.	.808
OTL earth science f	6.7836	5.121	.363	.	.825
OTL earth science g	6.1852	5.199	.553	.	.812
OTL earth science h	6.2752	5.208	.383	.	.822
OTL earth science i	6.6790	4.958	.435	.	.819
OTL earth science j	6.4908	4.977	.432	.	.819
OTL earth science k	6.4019	5.015	.447	.	.818

Topic coverage (Obiology)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.766	.772	12

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.474	.178	.890	.712	5.011	.073	12
Item Variances	.119	.057	.165	.108	2.906	.001	12
Inter-Item Correlations	.220	-.107	.688	.796	-6.417	.021	12

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL biology a	5.3507	4.049	.375	.	.754
OTL biology b	4.9165	4.246	.310	.	.760
OTL biology c	4.8998	4.295	.278	.	.763
OTL biology d	4.8450	4.216	.439	.	.747
OTL biology e	4.7937	4.336	.402	.	.752
OTL biology f	5.4322	4.003	.467	.	.742
OTL biology g	5.2664	4.113	.312	.	.762
OTL biology h	5.5061	4.149	.419	.	.748
OTL biology i	5.4964	4.127	.444	.	.746
OTL biology j	5.4197	3.940	.508	.	.737
OTL biology k	5.3811	3.967	.466	.	.742
OTL biology l	5.2130	3.910	.460	.	.743

Topic coverage (Oenvironment)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.860	.863	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.208	.183	.246	.063	1.346	.001	3
Item Variances	.109	.102	.121	.019	1.187	.000	3
Inter-Item Correlations	.677	.543	.821	.278	1.513	.016	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL environment a	.4422	.375	.741	.674	.799
OTL environment b	.4294	.343	.844	.744	.702
OTL environment c	.3790	.375	.635	.446	.902

Type of homework (Knowledge homework)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.507	.517	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.916	.862	1.019	.157	1.182	.008	3
Item Variances	.191	.134	.267	.134	2.001	.005	3
Inter-Item Correlations	.263	.191	.311	.120	1.626	.003	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
homework on problem	1.7299	.473	.386	.151	.305
homework on application	1.8807	.574	.288	.094	.466
homework on textbook	1.8870	.394	.317	.108	.444

School principal questionnaire

School climate

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.898	.899	8

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.346	2.801	3.743	.941	1.336	.111	8
Item Variances	.824	.621	1.055	.434	1.698	.019	8
Inter-Item Correlations	.527	.350	.791	.441	2.262	.011	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
teacher job satisfaction-p	23.1397	25.454	.596	.457	.893
teacher understand goals	23.0221	24.348	.683	.551	.886
teacher degree of success	23.2353	23.974	.725	.616	.882
teacher expect student	23.2279	23.555	.737	.602	.880
parent support student	23.6029	22.937	.694	.711	.885
parent involve school	23.7941	23.365	.685	.652	.885
student regard school	23.9632	24.450	.616	.518	.892
student desire do well	23.3676	23.419	.735	.641	.880

Parent involvement

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.341	.360	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.759	.515	.868	.353	1.686	.027	4
Item Variances	.164	.116	.252	.136	2.175	.004	4
Inter-Item Correlations	.123	.049	.207	.157	4.196	.004	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
parent attend event	2.1691	.630	.248	.076	.217
parent volunteer project	2.5221	.518	.153	.026	.332
parent ensure homework	2.1985	.634	.185	.046	.274
parent serve committee	2.2206	.632	.156	.045	.305

Professional development

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.721	.726	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.118	.949	1.279	.331	1.349	.018	4
Item Variances	.313	.264	.366	.102	1.385	.003	4
Inter-Item Correlations	.399	.286	.644	.359	2.256	.016	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
develop curriculum	3.5221	1.792	.474	.233	.679
develop content knowledge	3.3382	1.618	.645	.476	.584
develop teaching skill	3.3603	1.521	.562	.427	.626
develop ICT	3.1912	1.771	.383	.152	.737

Student behaviour (Low moralef)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.815	.825	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.256	.713	1.647	.934	2.309	.151	5
Item Variances	1.063	.473	1.712	1.239	3.621	.291	5
Inter-Item Correlations	.485	.351	.617	.266	1.756	.008	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
frequency of late arrival	4.9044	9.391	.720	.533	.743
frequency of absenteeism	5.2721	11.800	.572	.357	.795
frequency of skipping	5.5662	12.351	.509	.267	.811
frequency of dress code	4.7426	8.963	.687	.480	.754
frequency of disturbance	4.6324	8.664	.637	.413	.779

Student behaviour (Bulleyingf)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.805	.814	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.763	.574	.941	.368	1.641	.024	5
Item Variances	.329	.232	.456	.224	1.963	.009	5
Inter-Item Correlations	.466	.367	.572	.205	1.560	.004	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
frequency of profanity	2.8750	2.821	.594	.399	.771
frequency of vandalism	3.0662	2.981	.574	.357	.775
frequency of theft	3.2426	3.311	.591	.394	.770
frequency of intimidating student	2.9265	3.224	.675	.468	.749
frequency of injury to student	3.1544	3.183	.564	.338	.776

Student behaviour (Low morales)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.848	.855	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.347	.235	.456	.221	1.938	.008	5
Item Variances	.257	.196	.324	.128	1.652	.003	5
Inter-Item Correlations	.541	.385	.661	.276	1.718	.009	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
severity of late arrival	1.4632	2.725	.697	.528	.809
severity of absenteeism	1.2794	2.692	.529	.317	.857
severity of skipping	1.5000	2.726	.740	.565	.800
severity of dress code	1.3529	2.630	.659	.479	.817
severity of disturbance	1.3456	2.524	.706	.530	.804

Instructional resources (Science resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.901	.901	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.270	1.213	1.316	.103	1.085	.002	4
Item Variances	.690	.641	.722	.081	1.126	.001	4
Inter-Item Correlations	.695	.603	.865	.262	1.434	.009	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
shortage of lab equipment	3.7941	5.187	.691	.510	.903
shortage of AV for science	3.7647	4.966	.744	.581	.885
shortage of computer for science	3.8676	4.723	.845	.789	.847
shortage of software for science	3.8162	4.892	.840	.793	.850

Instructional resources (Math resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.831	.839	6

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.074	.842	1.271	.429	1.509	.025	6
Item Variances	.705	.527	1.018	.491	1.933	.030	6
Inter-Item Correlations	.464	.282	.767	.485	2.717	.014	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
shortage for handicapped	5.2782	9.869	.451	.240	.843
shortage of computer for math	5.2857	9.448	.664	.629	.790
shortage of software for math	5.1729	9.811	.659	.651	.793
shortage of calculator for math	5.4962	9.555	.674	.509	.789
shortage of calculator for science	5.6015	10.226	.598	.427	.805
shortage of library for math	5.3835	10.314	.624	.421	.801

Instructional resources (Infra resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.761	.761	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.990	.868	1.110	.243	1.280	.015	3
Item Variances	.815	.778	.871	.094	1.120	.002	3
Inter-Item Correlations	.515	.498	.548	.049	1.099	.001	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
shortage of building and ground	2.1029	2.360	.604	.367	.667
shortage of heat/cool and light	1.8603	2.551	.567	.322	.707
shortage of space	1.9779	2.496	.606	.369	.665

Appendix H: Reliability analysis of the South African data

Student questionnaire

Home possession (11 items)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.793	.794	11

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.567	.338	.797	.459	2.356	.028	11
Item Variances	.220	.162	.250	.088	1.544	.001	11
Inter-Item Correlations	.259	.091	.448	.356	4.892	.006	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
computer at home	5.8931	7.588	.330	.137	.789
specific08 at home	5.8396	7.050	.534	.327	.767
specific12 at home	5.7947	7.170	.473	.262	.774
specific13 at home	5.8451	7.415	.385	.182	.784
dictionary at home	5.5162	7.652	.328	.121	.789
specific05 at home	5.4537	7.485	.446	.280	.777
specific06 at home	5.6035	7.346	.417	.229	.780
specific07 at home	5.4343	7.448	.485	.281	.774
specific09 at home	5.7105	7.077	.507	.285	.770
specific15 at home	5.7073	7.079	.506	.262	.770
specific16 at home	5.5178	7.169	.537	.349	.768

Liking science (Enjoying science)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.696	.691	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.256	3.068	3.473	.404	1.132	.027	4
Item Variances	1.046	.726	1.268	.542	1.747	.060	4
Inter-Item Correlations	.359	.245	.471	.227	1.927	.009	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
do well in science	9.7817	5.434	.504	.269	.618
take more science	9.7845	4.938	.537	.291	.595
learn science quickly	9.9568	4.791	.547	.320	.588
enjoy learning science	9.5526	6.527	.345	.125	.706

Liking science (Self-confidence)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.602	.602	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.440	2.387	2.476	.090	1.038	.002	3
Item Variances	1.163	1.121	1.185	.063	1.057	.001	3
Inter-Item Correlations	.335	.302	.370	.068	1.227	.001	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
science is more difficult	4.9328	3.080	.436	.191	.464
not understand a new topic	4.8432	3.077	.411	.173	.501
science is not strengths	4.8632	3.155	.384	.148	.540

Valuing science

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.796	.796	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.231	3.116	3.429	.313	1.100	.019	4
Item Variances	1.194	.982	1.334	.352	1.358	.023	4
Inter-Item Correlations	.494	.452	.574	.122	1.270	.002	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
for daily life	9.4948	7.701	.576	.332	.761
for other subjects	9.8075	7.257	.577	.333	.760
for university	9.7180	6.869	.631	.406	.733
for job I want	9.7510	6.649	.649	.427	.724

Learning activities (Inquiry Learning)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.697	.697	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.070	1.931	2.206	.275	1.142	.016	5
Inter-Item Correlations	.315	.221	.428	.207	1.940	.003	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
watch demonstration stu	8.42	7.775	.416	.183	.664
formulate hypothesis stu	8.14	7.615	.484	.238	.635
design experiment stu	8.26	7.410	.497	.261	.628
conduct experiment stu	8.18	7.462	.495	.257	.630
write explanation stu	8.41	8.131	.372	.141	.680

Learning activities (Lecture Learning)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.528	.528	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.667	1.607	1.717	.110	1.069	.003	3
Inter-Item Correlations	.272	.237	.319	.082	1.344	.001	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
present work stu	3.28	2.018	.351	.127	.411
review homework stu	3.32	2.107	.369	.137	.382
listen to lecture stu	3.39	2.307	.305	.094	.483

Liking school

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.803	.803	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.409	3.295	3.563	.268	1.081	.014	4
Item Variances	1.097	.902	1.191	.289	1.320	.018	4
Inter-Item Correlations	.504	.452	.583	.131	1.289	.002	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
like being in school	10.0721	7.271	.559	.314	.781
stu do the best	10.3405	6.573	.612	.375	.756
tch care about stu	10.2892	6.255	.658	.438	.733
tch want stu to do best	10.2046	6.366	.644	.424	.740

Safe school

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.401	.404	5

Inter-Item Correlation Matrix

	mine was stolen	hit or hurt by other stu	made to do things by oth stu	made fun of or called names	left out of activities
mine was stolen	1.000	.012	-.015	.070	-.026
hit or hurt by other stu	.012	1.000	.126	.167	.194
made to do things by oth stu	-.015	.126	1.000	.158	.313
made fun of or called names	.070	.167	.158	1.000	.196
left out of activities	-.026	.194	.313	.196	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.574	.456	.678	.221	1.485	.010	5
Item Variances	.237	.218	.250	.031	1.143	.000	5
Inter-Item Correlations	.119	-.026	.313	.339	-12.139	.011	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
mine was stolen	2.3896	1.473	.017	.007	.488
made fun of or called names	2.4139	1.212	.258	.070	.304
hit or hurt by other stu	2.1927	1.297	.214	.058	.341
made to do things by oth stu	2.2471	1.236	.253	.111	.310
left out of activities	2.2379	1.195	.299	.139	.272

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.502	.501	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.598	.480	.674	.194	1.403	.007	4
Item Variances	.235	.220	.250	.030	1.135	.000	4
Inter-Item Correlations	.201	.116	.301	.185	2.590	.003	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
made fun of or called names	1.91	.970	.294	.430
hit or hurt by other stu	1.72	1.062	.235	.481
made to do things by oth stu	1.78	.985	.297	.428
left out of activities	1.77	.943	.353	.376

Out-of school activities (Study after school)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.650	.650	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.952	2.787	3.126	.339	1.122	.029	3
Inter-Item Correlations	.383	.322	.414	.092	1.285	.002	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
do jobs at home	5.91	4.943	.438	.199	.584
read book for enjoy	6.07	5.056	.436	.198	.585
do homework	5.73	4.765	.508	.258	.487

Science teacher questionnaire

Preparation to teach (Pphysics & chemistry)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.933	.933	10

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.298	1.076	1.551	.475	1.441	.026	10
Item Variances	.447	.320	.534	.214	1.670	.004	10
Inter-Item Correlations	.582	.423	.759	.336	1.795	.008	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for chemistry a	11.4293	23.911	.663	.573	.930
ready for physics d	11.4343	23.719	.612	.527	.932
ready for chemistry b	11.6212	23.089	.755	.632	.925
ready for chemistry c	11.6869	22.551	.747	.642	.926
ready for chemistry d	11.7020	22.972	.710	.565	.927
ready for chemistry e	11.9040	22.260	.783	.657	.924
ready for physics a	11.7879	22.117	.793	.703	.923
ready for physics b	11.7020	22.403	.769	.641	.924
ready for physics c	11.8838	21.890	.801	.702	.923
ready for physics e	11.6667	22.741	.717	.585	.927

Preparation to teach (Pearth science & environment)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.916	.916	6

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.093	.970	1.273	.303	1.313	.013	6
Item Variances	.507	.453	.557	.104	1.230	.002	6
Inter-Item Correlations	.645	.491	.753	.262	1.533	.007	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for earth science a	5.5354	8.920	.772	.642	.899
ready for earth science b	5.5404	8.920	.786	.677	.897
ready for earth science c	5.5859	8.894	.760	.659	.901
ready for environment a	5.3788	9.292	.745	.627	.903
ready for environment b	5.2828	9.483	.700	.576	.909
ready for environment c	5.4545	8.879	.813	.703	.894

Preparation to teach (Pbiology)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.904	.904	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.474	1.242	1.591	.348	1.280	.018	5
Item Variances	.392	.365	.408	.043	1.118	.000	5
Inter-Item Correlations	.654	.557	.811	.254	1.457	.009	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ready for biology a	5.8687	4.440	.842	.758	.865
ready for biology b	5.8434	4.610	.792	.679	.876
ready for biology c	5.8586	4.508	.810	.701	.872
ready for biology e	5.7778	4.834	.715	.523	.893
ready for biology d	6.1263	4.862	.649	.438	.907

Professional development

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.747	.746	6

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.519	.348	.687	.338	1.971	.021	6
Item Variances	.233	.216	.249	.033	1.153	.000	6
Inter-Item Correlations	.329	.242	.477	.235	1.973	.006	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
develop content	2.4444	2.695	.506	.293	.705
develop science curriculum	2.5354	2.595	.540	.353	.694
develop science assessment	2.4242	2.824	.424	.198	.727
develop pedagogy/instruction	2.7323	2.634	.528	.296	.698
develop IT	2.7626	2.761	.450	.252	.720
develop inquiry skill	2.6566	2.704	.457	.244	.718

Attitudes toward subject (Inquiry practice)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.576	.575	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.384	3.258	3.490	.232	1.071	.010	4
Item Variances	.377	.344	.434	.090	1.260	.002	4
Inter-Item Correlations	.252	.207	.311	.104	1.504	.001	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
more than 1 representation	10.05	1.698	.356	.128	.505
solving by hypothesis	10.18	1.557	.404	.166	.464
scientific investigation	10.11	1.811	.313	.098	.538
modelling phenomena	10.28	1.755	.358	.133	.504

School setting

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.860	.861	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.338	2.101	2.465	.364	1.173	.042	3
Item Variances	.982	.924	1.051	.127	1.137	.004	3
Inter-Item Correlations	.673	.603	.747	.144	1.239	.004	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
safe neighbourhood	4.5657	3.161	.740	.577	.801
feel safe at school	4.5505	3.162	.792	.633	.751
security policy of school	4.9141	3.531	.679	.471	.855

School climate (High expectation)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.842	.843	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.532	2.192	2.995	.803	1.366	.113	4
Item Variances	1.229	1.162	1.326	.164	1.141	.005	4
Inter-Item Correlations	.572	.435	.712	.277	1.637	.010	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
parent support for student	7.6566	7.831	.650	.518	.813
parent involvement in school	7.9343	7.574	.739	.599	.773
student regard for school	7.6566	7.841	.710	.546	.786
student desire to do well	7.1313	8.368	.612	.447	.827

School climate (Professional teaching force)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.758	.766	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.533	3.237	3.813	.576	1.178	.057	4
Item Variances	1.001	.870	1.137	.267	1.307	.023	4
Inter-Item Correlations	.450	.282	.657	.376	2.335	.015	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
teacher job satisfaction	10.8939	5.811	.458	.229	.757
Teacher understand curriculum	10.5354	5.651	.622	.465	.668
teacher success in curriculum	10.6465	5.387	.698	.535	.627
teacher expectation for student	10.3182	5.721	.475	.281	.748

Content-related activities (Explanation work)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.671	.671	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.784	1.338	2.333	.995	1.743	.178	4
Item Variances	.717	.650	.786	.136	1.210	.003	4
Inter-Item Correlations	.338	.228	.503	.275	2.209	.008	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
technology on society	5.80	3.431	.514	.303	.563
learn nature and inquiry	5.52	3.429	.475	.286	.590
present work	5.29	3.790	.389	.176	.646
relate to daily life	4.80	3.763	.435	.199	.617

Content-related activities (Inquiry work)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.519	.519	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.359	1.298	1.444	.146	1.113	.006	3
Item Variances	.535	.508	.566	.058	1.114	.001	3
Inter-Item Correlations	.265	.251	.275	.025	1.099	.000	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
watch demonstration	2.78	1.301	.344	.118	.401
formulate hypotheses	2.74	1.400	.325	.106	.432
design experiment	2.63	1.361	.331	.110	.423

Factors limiting teaching (Physical resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.824	.829	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.957	1.753	2.040	.288	1.164	.013	5
Item Variances	1.233	1.115	1.406	.291	1.261	.013	5
Inter-Item Correlations	.493	.216	.807	.591	3.741	.047	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in other equipment	7.7778	11.290	.778	.709	.743
limit in equipment	7.7424	11.390	.783	.734	.742
limit in physical facility	7.8030	11.205	.741	.653	.752
limit in stu/tch ratio	7.7778	13.798	.328	.133	.873
limit in textbook	8.0303	12.750	.528	.346	.814

Factors limiting teaching (Computer resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.948	.948	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.975	1.970	1.985	.015	1.008	.000	3
Item Variances	1.707	1.700	1.715	.015	1.009	.000	3
Inter-Item Correlations	.859	.805	.936	.131	1.163	.004	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in hardware	3.9394	6.281	.908	.878	.911
limit in software	3.9545	6.145	.933	.896	.892
limit in using computer	3.9545	6.612	.834	.704	.967

Factors limiting teaching (Student morale)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.809	.810	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.591	1.545	1.677	.131	1.085	.006	3
Item Variances	.896	.859	.950	.090	1.105	.002	3
Inter-Item Correlations	.587	.505	.673	.168	1.333	.006	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
limit in uninterest	3.0960	2.889	.661	.473	.735
limit in low morale	3.2222	2.722	.722	.531	.671
limit disruptive student	3.2273	2.907	.594	.361	.805

Topic coverage (Ophysics)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.773	.775	10

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.470	.192	.737	.545	3.842	.047	10
Item Variances	.208	.156	.251	.095	1.611	.001	10
Inter-Item Correlations	.257	.064	.609	.545	9.516	.013	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL physics a	4.0556	5.494	.491	.343	.746
OTL physics b	4.0202	5.756	.380	.267	.761
OTL physics c	3.9798	5.908	.328	.170	.767
OTL physics g	3.9596	5.887	.350	.183	.764
OTL physics d	4.4293	5.515	.537	.384	.741
OTL physics e	4.5051	5.683	.528	.521	.744
OTL physics f	4.5051	5.835	.441	.435	.754
OTL physics h	4.3384	5.474	.501	.309	.745
OTL physics i	4.1818	5.703	.367	.221	.764
OTL physics j	4.2980	5.479	.484	.290	.747

Topic coverage (Ochemistry)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.742	.742	8

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.548	.364	.773	.409	2.125	.028	8
Item Variances	.225	.177	.244	.067	1.382	.001	8
Inter-Item Correlations	.265	.133	.422	.289	3.171	.008	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL chemistry a	3.6111	4.249	.402	.265	.722
OTL chemistry b	3.7273	3.986	.478	.316	.707
OTL chemistry c	3.6818	4.066	.457	.270	.711
OTL chemistry d	3.7172	4.092	.421	.207	.718
OTL chemistry e	3.9697	4.111	.383	.181	.726
OTL chemistry f	3.9899	3.919	.496	.291	.703
OTL chemistry g	3.9697	4.030	.428	.246	.717
OTL chemistry h	4.0202	4.071	.420	.262	.718

Topic coverage (Obiology)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.770	.769	11

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.579	.394	.707	.313	1.795	.014	11
Item Variances	.232	.208	.245	.037	1.175	.000	11
Inter-Item Correlations	.233	.030	.554	.525	18.770	.012	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL biology a	5.68	7.266	.415	.272	.753
OTL biology b	5.74	6.933	.527	.369	.739
OTL biology c	5.97	7.207	.401	.331	.754
OTL biology d	5.95	7.211	.397	.250	.755
OTL biology e	5.73	7.245	.401	.269	.754
OTL biology f	5.72	7.115	.457	.283	.748
OTL biology g	5.98	7.076	.458	.290	.747
OTL biology h	5.78	7.369	.335	.194	.762
OTL biology j	5.67	7.462	.337	.243	.761
OTL biology k	5.74	7.118	.450	.388	.748
OTL biology l	5.78	7.138	.430	.364	.751

Topic coverage (Oearth science)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.875	.876	11

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.343	.232	.485	.253	2.087	.004	11
Item Variances	.223	.179	.251	.072	1.400	.000	11
Inter-Item Correlations	.391	.264	.692	.428	2.626	.006	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL earth science a	3.4141	9.990	.577	.406	.865
OTL earth science b	3.3939	9.753	.654	.518	.859
OTL earth science c	3.4545	9.995	.595	.409	.863
OTL earth science d	3.2929	9.965	.558	.397	.866
OTL earth science e	3.5455	10.249	.573	.385	.865
OTL earth science f	3.4091	9.989	.575	.397	.865
OTL earth science g	3.4192	10.072	.550	.320	.867
OTL earth science h	3.4242	10.286	.477	.284	.871
OTL earth science i	3.4444	9.944	.609	.408	.863
OTL earth science j	3.4545	9.945	.614	.543	.862
OTL earth science k	3.5253	10.088	.615	.545	.862

Topic coverage (Oenvironment)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.742	.745	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.621	.475	.722	.247	1.521	.017	3
Item Variances	.225	.202	.251	.049	1.243	.001	3
Inter-Item Correlations	.494	.432	.614	.182	1.423	.009	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
OTL environment b	1.1414	.680	.614	.410	.607
OTL environment c	1.1970	.646	.615	.413	.600
OTL environment a	1.3889	.686	.483	.233	.760

Type of homework (Inquiry homework)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.567	.570	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.111	1.035	1.162	.126	1.122	.004	3
Item Variances	.293	.230	.349	.119	1.517	.004	3
Inter-Item Correlations	.307	.180	.380	.200	2.113	.010	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
homework on project	2.20	.880	.335	.147	.528
homework on investigation	2.17	.681	.478	.232	.300
homework on report	2.30	.728	.331	.131	.548

School principal questionnaire

School climate (Professional teaching force)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.750	.754	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.424	3.212	3.641	.429	1.134	.046	3
Item Variances	.631	.576	.726	.150	1.260	.007	3
Inter-Item Correlations	.505	.440	.607	.168	1.381	.006	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
teacher job satisfaction-p	7.0606	1.874	.507	.258	.756
teacher understand goals	6.6313	1.929	.606	.400	.636
teacher degree of success	6.8535	1.872	.629	.419	.608

Parent involvement

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.525	.587	3

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.953	.914	.995	.081	1.088	.002	3
Item Variances	.044	.005	.079	.074	15.619	.001	3
Inter-Item Correlations	.322	.232	.423	.191	1.821	.007	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
parent attend event	1.9091	.093	.461	.226	.199
parent volunteer project	1.9444	.063	.436	.191	.307
parent serve committee	1.8636	.179	.314	.108	.582

Professional development

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.886	.888	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.726	1.268	2.035	.768	1.606	.087	5
Item Variances	1.482	1.340	1.617	.277	1.207	.013	5
Inter-Item Correlations	.613	.467	.831	.364	1.780	.011	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
develop curriculum	6.8384	16.979	.654	.459	.878
develop content knowledge	6.7323	16.705	.783	.720	.849
develop teaching skill	6.5960	16.313	.788	.727	.847
develop school goal	6.9949	16.350	.797	.637	.845
develop ICT	7.3636	17.420	.616	.400	.887

Student behaviour (Bulleyingf)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.846	.851	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.492	1.131	1.682	.551	1.487	.047	5
Item Variances	1.301	.673	1.731	1.058	2.572	.155	5
Inter-Item Correlations	.534	.410	.686	.275	1.670	.007	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
frequency of profanity	5.7778	12.641	.619	.398	.829
frequency of vandalism	5.9394	12.737	.677	.515	.809
frequency of theft	5.9747	12.928	.720	.555	.797
frequency of intimidating student	5.8182	12.992	.715	.545	.799
frequency of injury to student	6.3283	15.684	.585	.402	.837

Student behaviour (Bulleyings)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.814	.816	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	.921	.763	1.066	.303	1.397	.013	5
Item Variances	.489	.385	.600	.215	1.558	.006	5
Inter-Item Correlations	.470	.336	.621	.285	1.849	.007	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
severity of profanity	3.7374	4.783	.577	.345	.786
severity of vandalism	3.5404	4.534	.569	.418	.791
severity of theft	3.6414	4.434	.676	.494	.755
severity of intimidating student	3.6616	4.763	.605	.448	.777
severity of injury to student	3.8434	4.965	.601	.407	.780

Student behaviour (Low morales)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.813	.813	4

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.081	.899	1.253	.354	1.393	.038	4
Item Variances	.465	.421	.518	.097	1.231	.002	4
Inter-Item Correlations	.521	.487	.559	.071	1.146	.001	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
severity of late arrival	3.0707	2.868	.618	.392	.771
severity of absenteeism	3.0758	2.893	.655	.435	.755
severity of skipping	3.4242	2.723	.639	.416	.761
severity of dress code	3.3990	2.891	.614	.380	.772

Instructional resources (Material resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.977	.977	11

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.123	1.904	2.283	.379	1.199	.012	11
Item Variances	1.453	1.341	1.545	.204	1.152	.004	11
Inter-Item Correlations	.796	.659	.946	.286	1.434	.004	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
shortage of computer for math	21.2374	118.131	.866	.864	.975
shortage of software for math	21.1970	118.555	.866	.869	.975
shortage of calculator for math	21.4495	120.553	.808	.862	.977
shortage of library for math	21.1869	118.112	.899	.871	.974
shortage of AV for math	21.2172	118.140	.912	.896	.974
shortage of computer for science	21.1111	118.353	.898	.907	.974
shortage of software for science	21.0707	118.472	.923	.927	.974
shortage of calculator for science	21.3737	118.611	.857	.898	.976
shortage of library for science	21.1919	118.328	.898	.908	.974
shortage of AV for science	21.2071	117.800	.921	.917	.974
shortage of computer staff	21.2929	118.665	.846	.758	.976

Instructional resources (Facility resource)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.780	.778	5

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.542	1.404	1.727	.323	1.230	.016	5
Item Variances	1.264	.993	1.477	.484	1.487	.051	5
Inter-Item Correlations	.413	.281	.634	.353	2.260	.014	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
shortage of building and ground	6.1616	10.451	.621	.471	.716
shortage of space	6.2677	10.766	.582	.441	.730
shortage of teacher	6.3081	12.874	.411	.181	.782
shortage of material	5.9848	11.660	.584	.410	.731
shortage of budget	6.1263	10.984	.580	.426	.730

Appendix I: Correlation analysis of the Korean data

Student questionnaire

Correlations

		science achievement*
student gender	Pearson Correlation	.092**
	Sig. (2-tailed)	.000
	N	4876
language at home	Pearson Correlation	.004
	Sig. (2-tailed)	.798
	N	4876
books at home	Pearson Correlation	.381**
	Sig. (2-tailed)	.000
	N	4876
mother education	Pearson Correlation	.236**
	Sig. (2-tailed)	.000
	N	4876
father education	Pearson Correlation	.260**
	Sig. (2-tailed)	.000
	N	4876
school level expected by student	Pearson Correlation	.365**
	Sig. (2-tailed)	.000
	N	4876
extra science lesson	Pearson Correlation	.177**
	Sig. (2-tailed)	.000
	N	4876
frequency of homework	Pearson Correlation	-.036*
	Sig. (2-tailed)	.013
	N	4876
time for homework	Pearson Correlation	.045**
	Sig. (2-tailed)	.002
	N	4876
liking science	Pearson Correlation	.407**
	Sig. (2-tailed)	.000
	N	4876
valuing science	Pearson Correlation	.340**
	Sig. (2-tailed)	.000
	N	4876
practical learning	Pearson Correlation	.163**
	Sig. (2-tailed)	.000
	N	4876
STS learning	Pearson Correlation	.198**

	Sig. (2-tailed)	.000
	N	4876
lecture learning	Pearson Correlation	.253**
	Sig. (2-tailed)	.000
	N	4876
liking school	Pearson Correlation	.071**
	Sig. (2-tailed)	.000
	N	4876
school safety	Pearson Correlation	.002
	Sig. (2-tailed)	.878
	N	4876
playing after school	Pearson Correlation	-.226**
	Sig. (2-tailed)	.000
	N	4876
study after school	Pearson Correlation	.272**
	Sig. (2-tailed)	.000
	N	4876
work after school	Pearson Correlation	-.110**
	Sig. (2-tailed)	.000
	N	4876

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Science teacher questionnaire

Correlations

		mean of class achievement
teaching experience	Pearson Correlation	.057
	Sig. (2-tailed)	.362
	N	256
scheduled time/week	Pearson Correlation	.245**
	Sig. (2-tailed)	.004
	N	137
scheduled time/week total	Pearson Correlation	.283**
	Sig. (2-tailed)	.001
	N	137
number of student in class	Pearson Correlation	.315**
	Sig. (2-tailed)	.001
	N	137
ready phy & earth	Pearson Correlation	.066
	Sig. (2-tailed)	.322
	N	225
ready chemistry	Pearson Correlation	.023
	Sig. (2-tailed)	.730
	N	228
ready biology	Pearson Correlation	.072
	Sig. (2-tailed)	.287
	N	220
ready environment	Pearson Correlation	.086
	Sig. (2-tailed)	.198
	N	227
teacher interaction	Pearson Correlation	.193**
	Sig. (2-tailed)	.005
	N	255
professional development	Pearson Correlation	.055
	Sig. (2-tailed)	.378
	N	256
inquiry practice	Pearson Correlation	-.032
	Sig. (2-tailed)	.615
	N	250
knowledge practice	Pearson Correlation	-.060
	Sig. (2-tailed)	.341
	N	253
school environment	Pearson Correlation	.045

	Sig. (2-tailed)	.472
	N	254
high expectation	Pearson Correlation	.285**
	Sig. (2-tailed)	.000
	N	255
professional teaching force	Pearson Correlation	.061
	Sig. (2-tailed)	.333
	N	255
practical work	Pearson Correlation	.032
	Sig. (2-tailed)	.620
	N	248
inquiry work	Pearson Correlation	.077
	Sig. (2-tailed)	.226
	N	251
student resource	Pearson Correlation	-.062
	Sig. (2-tailed)	.325
	N	251
physical resource	Pearson Correlation	-.057
	Sig. (2-tailed)	.371
	N	249
computer resource	Pearson Correlation	-.006
	Sig. (2-tailed)	.924
	N	249
OTLphysics	Pearson Correlation	.003
	Sig. (2-tailed)	.968
	N	235
OTLchemistry	Pearson Correlation	-.049
	Sig. (2-tailed)	.453
	N	239
OTLenvironment	Pearson Correlation	-.071
	Sig. (2-tailed)	.274
	N	237
OTLearthscience	Pearson Correlation	.016
	Sig. (2-tailed)	.806
	N	235
OTLbiology	Pearson Correlation	-.086
	Sig. (2-tailed)	.198
	N	227

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

School principal questionnaire

Correlations

		mean of class achievement
enrolment of all grades	Pearson Correlation	.471**
	Sig. (2-tailed)	.000
	N	137
enrolment of eighth grade	Pearson Correlation	.454**
	Sig. (2-tailed)	.000
	N	136
type of community	Pearson Correlation	.369**
	Sig. (2-tailed)	.000
	N	134
percent of disadvantaged	Pearson Correlation	-.509**
	Sig. (2-tailed)	.000
	N	131
percent of advantaged	Pearson Correlation	.446**
	Sig. (2-tailed)	.000
	N	129
instruction day per year	Pearson Correlation	-.118
	Sig. (2-tailed)	.177
	N	133
total computers in school	Pearson Correlation	.208*
	Sig. (2-tailed)	.019
	N	130
educational ethos	Pearson Correlation	.414**
	Sig. (2-tailed)	.000
	N	137
professional development	Pearson Correlation	.229**
	Sig. (2-tailed)	.007
	N	133
low morale	Pearson Correlation	-.032
	Sig. (2-tailed)	.711
	N	137
frequency of bullying	Pearson Correlation	.172*
	Sig. (2-tailed)	.045
	N	137
frequency of disrespect	Pearson Correlation	.022
	Sig. (2-tailed)	.794
	N	137
severity of low morale	Pearson Correlation	-.015

	Sig. (2-tailed)	.862
	N	135
severity of disrespect	Pearson Correlation	-.153
	Sig. (2-tailed)	.075
	N	136
resource(science)	Pearson Correlation	-.051
	Sig. (2-tailed)	.553
	N	136
resource(math)	Pearson Correlation	-.157
	Sig. (2-tailed)	.071
	N	133
resource(infrastructure)	Pearson Correlation	.056
	Sig. (2-tailed)	.515
	N	136
budget	Pearson Correlation	.003
	Sig. (2-tailed)	.968
	N	135

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix J: Correlation analysis of the South Africa data

Student questionnaire

Correlations

	science achievement *	
student age	Pearson Correlation	.318**
	Sig. (2-tailed)	.000
	N	6423
student gender	Pearson Correlation	.013
	Sig. (2-tailed)	.286
	N	6784
language at home	Pearson Correlation	.447**
	Sig. (2-tailed)	.000
	N	6784
books at home	Pearson Correlation	.213**
	Sig. (2-tailed)	.000
	N	6784
extra science lesson	Pearson Correlation	-.377**
	Sig. (2-tailed)	.000
	N	6784
frequency of homework	Pearson Correlation	-.122**
	Sig. (2-tailed)	.000
	N	6784
time for homework	Pearson Correlation	.033**
	Sig. (2-tailed)	.007
	N	6784
student born-in country	Pearson Correlation	.355**
	Sig. (2-tailed)	.000
	N	6784
home possession	Pearson Correlation	.475**
	Sig. (2-tailed)	.000
	N	6784
attitude toward science (enjoying)	Pearson Correlation	.060**
	Sig. (2-tailed)	.000
	N	6784
attitude toward science (self-confidence)	Pearson Correlation	.384**
	Sig. (2-tailed)	.000
	N	6784
attitude toward science (valuing)	Pearson Correlation	-.047**
	Sig. (2-tailed)	.000

	N	6784
learning practice (inquiry-centred)	Pearson Correlation	-.094**
	Sig. (2-tailed)	.000
	N	6784
learning practice (student-centred))	Pearson Correlation	-.081**
	Sig. (2-tailed)	.000
	N	6784
learning practice (lecture-centred)	Pearson Correlation	-.089**
	Sig. (2-tailed)	.000
	N	6784
school climate (liking school)	Pearson Correlation	.044**
	Sig. (2-tailed)	.000
	N	6784
school climate (safety)	Pearson Correlation	.351**
	Sig. (2-tailed)	.000
	N	6784
mass media	Pearson Correlation	-.274**
	Sig. (2-tailed)	.000
	N	6784
study after school	Pearson Correlation	.041**
	Sig. (2-tailed)	.000
	N	6784

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Science teacher questionnaire

Correlations

		mean of class achievement
age of teacher	Pearson Correlation	.324**
	Sig. (2-tailed)	.000
	N	198
teaching experience	Pearson Correlation	.320**
	Sig. (2-tailed)	.000
	N	198
teacher education	Pearson Correlation	.254**
	Sig. (2-tailed)	.000
	N	198
complete first degree	Pearson Correlation	.366**
	Sig. (2-tailed)	.000
	N	198
license type	Pearson Correlation	.298**
	Sig. (2-tailed)	.000
	N	198
scheduled time/week	Pearson Correlation	.210**
	Sig. (2-tailed)	.003
	N	198
science teaching time/ week	Pearson Correlation	-.209**
	Sig. (2-tailed)	.003
	N	198
school facility repair	Pearson Correlation	.535**
	Sig. (2-tailed)	.000
	N	198
number of student in a class	Pearson Correlation	-.282**
	Sig. (2-tailed)	.000
	N	198
textbook use	Pearson Correlation	-.293**
	Sig. (2-tailed)	.000
	N	198
computer in science lesson	Pearson Correlation	.412**
	Sig. (2-tailed)	.000
	N	198
ready to teach physics & chemistry	Pearson Correlation	.156*
	Sig. (2-tailed)	.029
	N	198
ready to teach biology	Pearson Correlation	.043

	Sig. (2-tailed)	.552
	N	198
interaction by discussion or preparation	Pearson Correlation	.001
	Sig. (2-tailed)	.984
	N	198
interaction by visit or observation	Pearson Correlation	-.246**
	Sig. (2-tailed)	.000
	N	198
school climate (safety)	Pearson Correlation	.301**
	Sig. (2-tailed)	.000
	N	198
high expectation (parent & student)	Pearson Correlation	.173*
	Sig. (2-tailed)	.015
	N	198
professional teaching force	Pearson Correlation	.099
	Sig. (2-tailed)	.164
	N	198
STS work	Pearson Correlation	-.262**
	Sig. (2-tailed)	.000
	N	198
practical work	Pearson Correlation	-.150*
	Sig. (2-tailed)	.035
	N	198
physical resource	Pearson Correlation	-.489**
	Sig. (2-tailed)	.000
	N	198
computer resource	Pearson Correlation	-.357**
	Sig. (2-tailed)	.000
	N	198
student resource (SES)	Pearson Correlation	-.230**
	Sig. (2-tailed)	.001
	N	198
OTL for biology	Pearson Correlation	-.172*
	Sig. (2-tailed)	.016
	N	198
inquiry-based homework	Pearson Correlation	-.185**
	Sig. (2-tailed)	.009
	N	198
knowledge-based homework	Pearson Correlation	-.188**
	Sig. (2-tailed)	.008
	N	198
homework for correct, discuss, & grade	Pearson Correlation	.018
	Sig. (2-tailed)	.802

	N	198
homework for monitor & feedback	Pearson Correlation	-.203**
	Sig. (2-tailed)	.004
	N	198

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

School principal questionnaire

Correlations

		mean of class achievement
enrolment of all grades	Pearson Correlation	.301**
	Sig. (2-tailed)	.000
	N	198
enrolment of eighth grade	Pearson Correlation	.222**
	Sig. (2-tailed)	.002
	N	197
type of community	Pearson Correlation	.367**
	Sig. (2-tailed)	.000
	N	198
percent of student still	Pearson Correlation	.295**
	Sig. (2-tailed)	.000
	N	198
percent of absent student	Pearson Correlation	-.197**
	Sig. (2-tailed)	.005
	N	198
percent of 1st language	Pearson Correlation	.609**
	Sig. (2-tailed)	.000
	N	198
percent of disadvantaged	Pearson Correlation	-.616**
	Sig. (2-tailed)	.000
	N	198
percent of advantaged	Pearson Correlation	.553**
	Sig. (2-tailed)	.000
	N	198
principal administrative duty	Pearson Correlation	.324**
	Sig. (2-tailed)	.000
	N	198
principal instruction leadership	Pearson Correlation	-.056
	Sig. (2-tailed)	.431
	N	198
principal supervise & evaluate	Pearson Correlation	-.230**
	Sig. (2-tailed)	.001
	N	198
professional teaching force	Pearson Correlation	.302**
	Sig. (2-tailed)	.000
	N	198
high expectation	Pearson Correlation	.209**

	Sig. (2-tailed)	.000
	N	198
professional development	Pearson Correlation	-.026
	Sig. (2-tailed)	.712
	N	198
frequency of bullying 6	Pearson Correlation	.175*
	Sig. (2-tailed)	.014
	N	198
frequency of low morale	Pearson Correlation	-.062
	Sig. (2-tailed)	.386
	N	198
severity of low morale	Pearson Correlation	-.208
	Sig. (2-tailed)	.003
	N	198
material resource	Pearson Correlation	-.182*
	Sig. (2-tailed)	.010
	N	198
facility resource	Pearson Correlation	-.442**
	Sig. (2-tailed)	.000
	N	198

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix K: Multilevel analysis of the Korean data

The models built as variables added

Fixed effects	Null model	Model-1	Model-2	Model-3	Model-4	Model-5
Student level	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	558.307(1.878)	444.409(4.068)	406.757(4.091)	339.547(5.354)	337.661(5.314)	327.858(5.473)
Liksci		6.847(0.224)	5.947(0.215)	5.223(0.212)	4.945(0.213)	4.936(0.212)
Bokhom			16.477(0.690)	13.982(0.681)	12.862(0.688)	11.960(0.703)
Edustu				21.900(1.182)	20.984(1.178)	19.802(1.190)
Timafsch					5.739(0.663)	5.620(0.661)
Edudad						3.497(0.552)
Extutor						
Class/school level						
Disadva						
Schsize						
Hixpect						
Prodeve						
Random effects						
σ^2_e	4646.078(95.445)	3909.223(80.296)	3529.599(72.508)	3301.747(67.827)	3254.277(66.852)	3241.765(66.597)
σ^2_{u0}	350.446(58.353)	256.107(44.445)	154.426(30.784)	133.741(27.498)	125.767(26.363)	96.072(22.695)
Deviance	*55187.250*	*54331.510*	*53797.330*	*53465.630*	*53391.280*	*53352.730*

Fixed effects	Null model	Model-6	Model-7	Model-8	Model-9	Model-10
Student level	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	558.307(1.878)	329.016(5.459)	344.451(6.101)	336.240(7.006)	325.807(9.262)	319.418(9.634)
Liksci		4.821(0.212)	4.802(0.211)	4.771(0.211)	4.771(0.211)	4.759(0.211)
Bokhom		11.901(0.701)	11.811(0.699)	11.799(0.699)	11.797(0.699)	11.779(0.698)
Edustu		18.901(1.199)	18.883(1.196)	18.998(1.196)	19.002(1.196)	18.993(1.195)
Timafsch		5.715(0.659)	5.687(0.657)	5.678(0.657)	5.680(0.656)	5.683(0.656)
Edudad		3.352(0.551)	3.138(0.549)	2.981(0.553)	2.921(0.554)	2.878(0.554)
Extutor		3.360(0.639)	3.368(0.636)	3.308(0.636)	3.297(0.636)	3.309(0.636)
Class/school level						
Disadva			-6.715(1.149)	-5.992(1.173)	-5.492(1.199)	-5.417(1.181)
Schsize				1.842(0.791)	1.847(0.784)	1.656(0.776)
Hixpect					0.636(0.373)	0.747(0.371)
Prodeve						1.305(0.614)
Random effects						
σ^2_e	4646.078(95.445)	3225.629(66.264)	3225.124(66.249)	3224.321(66.231)	3224.072(66.225)	3223.994(66.223)
σ^2_{u0}	350.446(58.353)	91.298(22.076)	55.313(17.726)	50.917(17.197)	48.339(16.885)	43.997(16.357)
Deviance	*55187.250*	*53325.210*	*53294.430*	*53289.070*	*53286.180*	*53281.750*

The portion of variance explained

Model	Null model		Model-1		Model-2		Model-3		Model-4		Model-5	
Student level		SE		SE		SE		SE		SE		SE
Variance	4646.078	95.445	3909.223	80.296	3529.599	72.508	3301.747	67.827	3254.277	66.852	3241.765	66.597
Explained proportion of variance over null model			15.8%		24.0%		28.9%		30.0%		30.2%	
Explained proportion of variance over last model					8.2%		4.9%		1.1%		0.2%	
Class/school level												
Variance	350.446	58.353	256.107	44.445	154.426	30.784	133.741	27.498	125.767	26.363	96.072	22.695
Explained proportion of variance over null model			26.9%		55.9%		61.8%		64.1%		72.6%	
Explained proportion of variance over last model					29%		5.9%		2.3%		8.5%	

Model	Null model		Model-6		Model-7		Model-8		Model-9		Model-10	
Student level		SE		SE		SE		SE		SE		SE
Variance	4646.078	95.445	3225.629	66.264	3225.124	66.249	3224.321	66.231	3224.072	66.225	3223.994	66.223
Explained proportion of variance over null model			30.6%		30.6%		30.6%		30.6%		30.6%	
Explained proportion of variance over last model			0.4%		0		0		0		0	
Class/school level												
Variance	350.446	58.353	91.298	22.076	55.313	17.726	50.917	17.197	48.339	16.885	43.997	16.357
Explained proportion of variance over null model			73.9%		84.2%		85.5%		86.2%		87.4%	
Explained proportion of variance over last model			1.3%		10.3%		1.3%		0.7%		1.2%	

Appendix L: Multilevel analysis of the South African data

The models built as variables added

Fixed effects	Null model	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
Student level	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	245.040(7.223)	166.037(7.434)	141.855(7.166)	113.579(7.149)	134.474(7.161)	126.980(7.903)	108.282(6.924)
Selfcon		10.662(0.433)	9.594(0.422)	8.892(0.418)	8.405(0.417)	8.059(0.415)	8.095(0.413)
Boncnty			49.201(2.274)	45.182(2.251)	43.949(2.236)	42.970(2.221)	42.881(2.209)
Agestu				11.668(0.754)	11.422(0.748)	10.850(0.745)	10.968(0.740)
Extutor					-10.880(0.982)	-10.560(0.975)	-10.653(0.969)
Media						7.214(0.700)	6.947(0.697)
Languag							13.931(1.349)
Hompos							
Class/School level							
Safschag							
Disadva							
Phyres							
1stdeg							
Admindt							
Agetch							
Textuse							
Clasize							
STS							
Supevdt							
Lomoral							
Random effects							
$\sigma^2 e$	7034.088(122.582)	6469.732(112.761)	6059.104(105.616)	5860.922(102.134)	5769.945(100.550)	5684.650(99.064)	5626.339(98.047)
$\sigma^2 u_0$	10109.060(1037.217)	8700.362(891.247)	7822.930(800.012)	7196.814(741.657)	6554.918(676.614)	6315.258(652.169)	5262.551(546.429)
Deviance	*80118.130*	*79537.900*	*79085.200*	*78849.910*	*78728.760*	*78623.410*	*78520.400*

Fixed effects	Null model	Model-7	Model-8	Model-9	Model-10	Model-11	Model-12
Student level	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	245.040(7.223)	92.750(7.032)	-107.161(17.096)	118.569(28.581)	133.796(27.141)	122.041(26.600)	106.712(26.507)
Selfcon		8.162(0.412)	8.070(0.412)	8.066(0.412)	8.068(0.411)	8.079(0.411)	8.077(0.411)
Boncnty		43.060(2.204)	42.355(2.199)	42.173(2.192)	41.969(2.190)	42.002(2.188)	41.967(2.187)
Agestu		10.809(0.739)	10.823(0.737)	10.923(0.735)	10.927(0.734)	10.921(0.734)	10.896(0.734)
Extutor		-10.638(0.967)	-10.338(0.967)	-10.212(0.965)	-10.190(0.964)	-10.128(0.964)	-10.111(0.964)
Media		6.360(0.701)	6.305(0.701)	6.416(0.700)	6.413(0.700)	6.428(0.700)	6.426(0.700)
Languag		13.319(1.351)	13.192(1.343)	13.210(1.334)	13.137(1.331)	13.143(1.329)	13.105(1.328)
Hompos		2.805(0.413)	2.774(0.412)	2.785(0.410)	2.778(0.409)	2.813(0.409)	2.777(0.409)
Class/School level							
Safschag			83.491(6.885)	61.662(6.218)	58.295(5.898)	56.146(5.768)	53.592(5.708)
Disadva				-46.179(5.044)	-37.960(5.006)	-36.174(4.892)	-34.713(4.811)
Phyres					-3.860(0.754)	-3.336(0.749)	-3.536(0.736)
1stdeg						26.462(7.938)	22.988(7.853)
Admindt							5.671(1.871)
Agetch							
Textuse							
Clasize							
STS							
Supevdt							
Lomoral							
Random effects							
σ^2_e	7034.088(122.582)	5609.017(97.749)	5608.681(97.761)	5609.134(97.762)	5608.300(97.741)	5608.880(97.752)	5608.495(97.743)
σ^2_{u0}	10109.060(1037.217)	4633.674(482.463)	2549.177(271.669)	1725.937(189.860)	1510.387(168.588)	1415.564(159.003)	1348.337(152.366)
Deviance	*80118.130*	*78475.770*	*78362.880*	*78292.140*	*78267.340*	*78256.530*	*78247.510*

Fixed effects	Null model	Model-13	Model-14	Model-15	Model-16	Model-17	Model-18
Student level	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)	Coefficient(SE)
Intercept	245.040(7.223)	67.710(28.545)	87.230(29.179)	104.684(29.732)	121.482(30.288)	134.433(30.167)	135.674(29.915)
Selfcon		8.077(0.411)	8.080(0.411)	8.097(0.411)	8.112(0.411)	8.110(0.411)	8.102(0.411)
Boncnty		42.079(2.186)	42.102(2.185)	42.038(2.185)	41.983(2.184)	41.859(2.183)	41.934(2.183)
Agestu		10.861(0.734)	10.852(0.733)	10.871(0.733)	10.872(0.733)	10.892(0.733)	10.868(0.733)
Extutor		-10.096(0.964)	-10.077(0.963)	-10.038(0.963)	-10.009(0.963)	-9.984(0.963)	-9.983(0.963)
Media		6.431(0.699)	6.442(0.699)	6.443(0.699)	6.450(0.699)	6.445(0.699)	6.453(0.699)
Languag		13.094(1.326)	13.150(1.325)	13.060(1.325)	12.995(1.325)	12.943(1.324)	13.029(1.323)
Hompos		2.752(0.409)	2.743(0.409)	2.770(0.409)	2.786(0.409)	2.808(0.408)	2.809(0.408)
Class/School level							
Safschag		52.675(5.586)	50.592(5.562)	49.644(5.499)	49.633(5.430)	50.148(5.340)	49.986(5.295)
Disadva		-32.126(4.767)	-30.741(4.725)	-30.612(4.659)	-30.793(4.600)	-28.724(4.583)	-27.896(4.566)
Phyres		-3.520(0.719)	-3.317(0.713)	-3.064(0.710)	-2.802(0.710)	-3.124(0.708)	-3.050(0.703)
1stdeg		21.980(7.679)	22.500(7.564)	20.097(7.527)	17.874(7.494)	18.051(7.361)	16.977(7.322)
Admindt		5.231(1.833)	5.139(1.805)	5.190(1.780)	4.974(1.759)	3.461(1.818)	3.809(1.813)
Agetch		10.815(3.357)	11.808(3.331)	11.247(3.291)	10.885(3.252)	10.625(3.195)	10.891(3.171)
Textuse			-26.628(10.580)	-26.682(10.429)	-24.868(10.324)	-28.697(10.243)	-28.560(10.153)
Clasize				-3.843(1.634)	-3.816(1.613)	-3.128(1.606)	-2.878(1.598)
STS					-2.572(1.133)	-2.251(1.119)	-2.197(1.109)
Supevdt						-7.228(2.719)	-6.592(2.718)
Lomoral							-2.165(1.217)
Random effects							
σ^2_e	7034.088(122.582)	5607.716(97.727)	5607.620(97.724)	5607.814(97.727)	5607.899(97.729)	5608.069(97.732)	5608.399(97.738)
σ^2_{u0}	10109.060(1037.217	1278.829(145.525)	1234.521(141.110)	1194.678(137.114)	1159.314(133.559)	1112.017(128.796)	1089.370(126.504)
Deviance	*80118.130*	*78237.350*	*78231.120*	*78225.660*	*78220.580*	*78213.620*	*78210.480*

The portion of variance explained

Model	Null model	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
Student level							
Variance	7034.088	6469.732	6059.104	5860.922	5769.945	5684.650	5626.339
Explained proportion of variance over null model		8.0%	13.9%	16.7%	18.0%	19.2%	20.0%
Explained proportion of variance over last model			5.9%	2.8%	1.3%	1.2%	0.8%
Class-school level							
Variance	10109.060	8700.362	7822.930	7196.814	6554.918	6315.258	5262.551
Explained proportion of variance over null model		13.9%	22.6%	28.8%	35.2%	37.5%	47.9%
Explained proportion of variance over last model			8.7%	6.2%	6.4%	2.3%	10.4%

Model	Null model	Model-7	Model-8	Model-9	Model-10	Model-11	Model-12
Student level							
Variance	7034.088	5609.017	5608.681	5609.134	5608.300	5608.880	5608.495
Explained proportion of variance over null model		20.3%	20.3%	20.3%	20.3%	20.3%	20.3%
Explained proportion of variance over last model		0.3%	0	0	0	0	0
Class-school level							
Variance	10109.060	4633.674	2549.177	1725.937	1510.387	1415.564	1348.337
Explained proportion of variance over null model		54.2%	74.8%	82.9%	85.1%	86.0%	86.7%
Explained proportion of variance over last model		6.3%	24%	8.1%	2.2%	0.9%	0.7%

Model	Null model	Model-13	Model-14	Model-15	Model-16	Model-17	Model-18
Student level							
Variance	7034.088	5607.716	5607.620	5607.814	5607.899	5608.069	5608.399
Explained proportion of variance over null model		20.3%	20.3%	20.3%	20.3%	20.3%	20.3%
Explained proportion of variance over last model		0	0	0	0	0	0
Class-school level							
Variance	10109.060	1278.829	1234.521	1194.678	1159.314	1112.017	1089.370
Explained proportion of variance over null model		87.3%	87.8%	88.2%	88.5%	89.0%	89.2%
Explained proportion of variance over last model		0.6%	0.5%	0.4%	0.3%	0.5%	0.2%