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