CHAPTER 1

INTRODUCING THE STUDY

1.1 INTRODUCTION

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

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

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

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

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

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

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

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

1.2 EDUCATION IN KOREA

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

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

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

1.2.1 EDUCATIONAL CONTEXTS IN KOREA

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.2.2 THE SCHOOLING SYSTEM IN KOREA

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

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

1.2.3 THE SCIENCE CURRICULUM IN KOREA

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

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

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

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

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

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

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

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

1.2.4 SCIENCE ACHIEVEMENT IN INTERNATIONAL STUDIES

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

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

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

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

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

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

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

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

1.3 EDUCATION IN SOUTH AFRICA

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

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

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

1.3.1 EDUCATIONAL CONTEXTS IN SOUTH AFRICA

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.3.2 THE SCHOOLING SYSTEM IN SOUTH AFRICA

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

1.3.3 THE SCIENCE CURRICULUM IN SOUTH AFRICA

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

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

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

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

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

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

1.3.4 SCIENCE ACHIEVEMENT IN INTERNATIONAL STUDIES

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

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

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

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

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

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

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

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

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

1.4 PROBLEM STATEMENT

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

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

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

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

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

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

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

1.5 RATIONALE FOR THE STUDY

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

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

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

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

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

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

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

1.6 AIMS OF THE STUDY

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

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

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

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

1.7 RESEARCH QUESTIONS

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

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

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

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

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

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

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

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

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

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

1.8 STRUCTURE OF THE DISSERTATION

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

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

1.9 CONCLUSION

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

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

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

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