The Attitudes of First Year Senior Secondary School Students toward Their Science Classes in the Sudan

A dissertation presented to

the faculty of

The Gladys W. and David H. Patton College of Education and Human Services

of Ohio University

In partial fulfillment

of the requirements for the degree

Doctor of Education

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June 2011

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This dissertation titled

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Their Science Classes in the Sudan

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Abstract

LADO, LONGUN MOSES, Ed. D., June 2011, Educational Administration

The Attitudes of First Year Senior Secondary School Students toward their Science Classes in the Sudan

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This study examined the influence of a set of relevant independent variables on students’ decision to major in math or science disciplines, on the one hand, or arts or humanities disciplines, on the other. The independent variables of interest in the study were students’ attitudes toward science, their gender, their socioeconomic status, their age, and the strength and direction of parents’ and peers’ influences on their academic decisions.

The study answered five research questions that concerned students’ intention in math or science, the association between students’ attitudes and their choice to major in math or science, the extent to which parents’ and peers’ perspectives influence students’ choice of major, and the influence of a combination of relevant variables on students’ choice of major.

The scholarly context for the study was literature relating to students’ attitudes toward science and math, their likelihood of taking courses or majoring in science or math and various conditions influencing their attitudes and actions with respect to enrollment in science or math disciplines. This literature suggested that students’ experiences, their gender, parents’ and peers’ influence, their socio-economic status, teachers’ treatment of them, school curricula, school culture, and other variables may
influence students’ attitudes toward science and math and their decision regarding the study of these subjects.

The study used a questionnaire comprised of 28 items to elicit information from students. Based upon cluster sampling of secondary schools, the researcher surveyed 1000 students from 10 secondary schools and received 987 responses.

The researcher used SPSS to analyze students’ responses. Descriptive statistics, logistic regression, and multiple regression analyses to provide findings that address the study’s research questions.

The following are the major findings from the study:

- The instrument used to measure students’ attitudes toward science and mathematics was not highly reliable, perhaps contributing to an attenuation of the relationship between attitude toward science and mathematics and choice of a science or mathematics major (rather than an arts or humanities major).
- Far more students than the researcher had anticipated provided responses indicating that they planned to major in a science or mathematics discipline rather than an arts or humanities discipline.
- Students’ attitudes towards math and science were more favorable than the researcher anticipated based on findings from previous related studies. This result suggests the possibility of social desirability bias in students’ responses.
- Three significant predictor variables contributed to a significant logistic regression equation in which choice of science or mathematics major was the dependent variable: gender (negative association), attitude toward science and
math (positive association), and peer influence 1 (positive association). Gender was the strongest predictor.

- Five significant predictor variables contributed to a significant multiple linear regression equation in which attitude toward science and mathematics was the dependent variable: peer influence 1 (positive association), parent influence 1 (positive association), parent influence 2 (positive association), books in home (positive association), and peer influence 2 (positive association).

The results reveal that among the targeted variables (gender, attitude, peer influence 1, peer influence 2, parent influence 1, parent influence 2, books in home, and age) only gender, peer influence 1, and attitude were significant predictors of students’ major in math or science.

Approved: _____________________________________________________________

Aimee A. Howley

Professor of Education
This dissertation is dedicated to Caroline, Sunday, Nyoka, Lim, Martin, Yapata, Nancy, Emmanuel (children), Moses Lado (father) and memory of my mother, late Artenza Meling Lasuba.
Acknowledgments

My sincere gratitude go to professor Aimee A. Howley who not only was a mentor but was also a resource person from the beginning till the end of my doctorate studies; Ohio university and American Showa Inc., for financial support; ROSE (University of Oslo) for material support; and members of my dissertation committee Drs. Danielle Dani, Larry Burgess, Bill Larson; friends Gilbert Kanyongo and family, Drs. Douglas Mpondi, Noelle Hunter, Sam Laki for their insights, unweaving support, and encouragement without which it would have been impossible to complete my studies. I also thank members of my family (especially Nyoka Na Jinga, sisters Senya and Sadia) for their patience and encouragement all along. My sincere thanks also go to my primary school mentor, Edward Taban Nyerere for his contribution towards foundation of my education.

I also wish to extend my sincere gratitude to Mawa, Francis, Lim, Ustaz Gama, secondary school interviewees and secondary school principals who contributed and dedicated their invaluable time to the task of data collection in the Sudan; and TAD staff of Ohio University for type setting of the final draft dissertation.
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Chapter One: Introduction

Background of the Study

This study examined the influence of a set of relevant independent variables on Sudanese students’ decision to major in a science discipline, on the one hand, or an arts and humanities discipline, on the other. The independent variables were students’ attitudes toward science, their gender, their socioeconomic status, and the strength and direction of parents’ and peers’ influences on their decisions. The circumstances making such a study relevant to an understanding of education in Sudan relate to the connection that many scholars believe exists between a country’s scientific and technical expertise and its economic development.

The chapter first looks at this purported connection and then it turns to a consideration of an important contextual factor—the history of education in sub-Saharan Africa in general and Sudan in particular. Following this retrospective look at education, the chapter considers contemporary calls for educational reform as these pertain in particular to science education. The chapter then provides a problem statement with applicable research questions and explains the significance of the study.

The Relationship between Scientific Expertise and Economic Development

In considering the plight of Sub-Saharan Africa, many scholars have drawn on theories from the social sciences to try to understand as well as to find ways for nations in the region to benefit from the relationship between education and economic development (Okwach & Obagi, 2005). These scholars are aware, of course, that most such theories

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1 In Sudan, the term “science major” refers to a concentration in studies related to the sciences and mathematics.
originated in Western countries and were applied by colonial authorities and, later, donor organizations to Sub-Saharan Africa in the hope that they would fit equally well with the circumstances confronting that region. The introduction of these theories, however, did not lead directly to the enhancement of science education. Rather, the theories contributed to generalized concern about educational policy, which in turn prompted governments to make major curriculum changes in the effort to advance economic development in their countries (Mutua & Sunal, 2004).

Many African scholars viewed the application of Western education theories with skepticism and saw them as related only tangentially either to progress in science or to economic development (Egbo, 2000; Okwach & Obagi, 2005). The five most common theories of education cited among African scholars as having been applied to the African circumstance and valued by policy makers because of their contributions toward science, technology, and economic development were (1) the structural-functionalist theory, (2) modernization theory, (3) human capital theory, (4) dependency theory, and (5) revitalization theory (Okwach & Obagi, 2005).

According to Okwach and Abagi (2005), the structural-functionalist theory of the 1930s viewed a society as a system of interdependent parts (e.g., family, religion, school, political structures, and economic structures). These societal substructures helped a society survive by continually working to promote equilibrium between the internal workings of the society and its external environment (Barker, 1988; Fagerlind & Saha, 1983). From this perspective, one important role of schooling was the selection and placement of individuals into various economic and status locations in the social structure in order to maintain stability.
Modernization theory, which originally emerged in the 1950s and retained prominence through the 1990s, extolled scientific practices and cast doubt on the value of traditional practices. Societies in developing countries were enjoined to modernize by using systematic planning as a way to bring about change (Okwach & Abagi, 2005). According to Okwach and Abagi (2005), modernization theory, in contrast to structural-functionalist theory, viewed schools as change agents whose role was to inculcate modern values and attitudes on behalf of scientific advancement and economic development.

Human capital theory, which was introduced in the 1960s, focused on schools’ role in preparing skilled workers (Okwach & Abagi, 2005). Based on economic theories explaining the return on investments in capital, the theory viewed schools as institutions for turning society’s investment in the development of human resources into measurable outcomes (Blaug, 1970; Karabel & Halsey, 1977).

By contrast, dependency theory, also introduced in the 1960s, was inspired by Marxism and put forth the argument that a fundamental economic conflict of interest had polarized nations into the poor and rich. From this perspective, dependency theorists concluded that Western countries developed at the expense of poor countries in other parts of the world (Rodney, 1981). Under dependency theory, the role of schools was to further the interests of richer countries by perpetuating knowledge, values, and attitudes that served to sustain the dominance of those countries.

One final theory, revitalization theory, also known as African renaissance theory, which was put forth originally in the 1960s, emphasized the use of indigenous capacity to promote national development. Its aim was to emancipate colonies by opposing foreign
control of their means of production. In addition, like Freire (1985), who talked about the process of “conscientization,” African renaissance theorists sought to raise critical awareness among the oppressed about their circumstances. This theory supported local ownership of the means of production as well as the training of community members in science on behalf of local enterprise.

Without paying much attention to the specifics of these theories of education or the distinctions among them, many policy makers in Sub-Sahara Africa acted as if a substantial investment in science education would produce skilled professionals in science and technology, which, in turn, would contribute to economic development (Sunal et al., 1998). Nevertheless, despite theoretical claims, only limited empirical evidence has confirmed a linkage between the preparation of professionals in science and technology and improvements in economic circumstances (Obagi, 2005).

Acknowledging the limited empirical support for this linkage, the author of this dissertation, along with many other researchers of education in Africa, nevertheless accepts as the theoretical basis for this study the purported influence of preparation in science on economic development. Of particular relevance is the view from human capital theory that schools prepare and produce a skilled labor force that contributes to progress (Baker, 1988; Fagerlind & Saha, 1983). Becker (2002), who stressed the importance of human capital in the alleviation of poverty in developing countries, concluded that human capital was the most important resource within any economy. Moreover, from his perspective human capital in large part was produced by formal education. In his view, significant growth in the economy would come primarily from the increase in human capital, which in turn would stimulate scientific and technological
changes. Similarly, Barro (2002) found that scientific activities and related technological innovations had positive influences on economic growth.

Furthermore, to a certain extent, revitalization theory was also relevant to the current study. This theory supports nationalization of the means of production as a basis for economic development. Both theories have contributed significantly to the evolving theory of an African renaissance, which promotes development through self-reliance (Nyerere, 1972). In keeping with both theories (i.e., human capital and revitalization) some writers and policy makers view improvements in both informal and formal science education as imperative to advancing the economic development of African communities (Birks & Fluitman, 1992; Fafunwa & Aisku, 1982; Nkulu, 2005; Obanya, 1999; Ogguniyi, 1988; Sunal et al., 1998). The alignment of these theories with regard to the importance of science education to prosperity and self-determination in Africa provided the practical rationale for conducting the study.

A Brief History of Education in Sub-Saharan Africa

The informal science education that preceded formal science education in Sub-Saharan Africa supported the types of local technology needed to produce goods and services for communities (Honig, 1998). This form of education drew on the oral tradition of knowledge transmission and was provided through communal apprenticeships outside of formal schools (Fafunwa & Aisku, 1982; Nkulu, 2005). Sunal, Jones, and Okebukola (1998) claimed that the informal transmission of science concepts promoted the development of various skills including skills in metal smelting and alloying, woodworking, textile and reeds dyeing, and pottery making.
The introduction of formal education, according to some writers, deterred progress in informal science education and gradually changed the attitudes of many Africans about the relevance of formal schools in general and science education in particular (Obanya, 1999; Ogunniyi, 1988; Sanderson & Sanderson, 1981). Formal science education in Sub-Sahara Africa was first presented in official schools at the primary, secondary and university levels with instruction provided in Arabic (Sunal et al., 1998). During the era of colonialism, Western languages dominated instruction in formal science classes (1988; Postlethwaite, 1995). For instance in Sudan, English replaced local languages and was the major language of instruction in schools (Sharkey, 2003).

A fairly substantial literature (e.g., Beshir, 1969; Sanderson & Sanderson, 1981; Sharkey, 2003) has pointed out that, during the colonial era in Sudan and many other African states, most science education was limited to the content needed to produce low-level technicians to meet the demands of the colonial governments. Indeed, these commentators claimed that, in general, the goal of colonial education was to provide functionaries to support colonial regimes. Sharkey (2003), for instance, explained that in 1902, Sudan’s Gordon Memorial College curriculum covered Arabic, English grammar, dictation, composition, handwriting, translation, arithmetic, and geography—studies focused on preparing government clerks. In 1905, the colonial government introduced special programs, one to produce teachers and Muslim judges and one to produce artisans who had the skills to construct bridges, brick kilns, and pipelines (Sharkey, 2003). According to Sanderson and Sanderson (1981), “...one of the major tasks of education in the Sudan was to produce adequate Sudanese junior officials, clerks and artisans to
replace expensive expatriates — Britain, Syrian and Egyptian [sic] — for employment in both the Northern and the Southern Sudan.” (p. 68).

Sanderson and Sanderson (1981) also explained that in Southern Sudan, Christian missions supported by colonial governments established three categories of formal schools. The first were mission schools intended to spread Christianity in the local communities as well as to prepare some local residents to serve as bible translators and spiritual leaders. The curriculum was dominated by numeracy, ethnic languages, English language, and bible studies. Second, colonial governments encouraged the development of regimented academic schools to produce literate military personnel, along with civil servants, clerks, and storekeepers. The regimented schools drew most students from the relatively privileged families of government functionaries. Graduates of these schools constituted what the colonial governments referred to as the fully literate group (Sanderson & Sanderson, 1981). Third, and far less prestigious than the regimented academic schools, were the industrial schools that served the children of villagers, slaves, and manual laborers. The curriculum in the industrial schools cultivated minimal levels of literacy in writing, reading, and numeracy, in other words, whatever limited academic knowledge was needed by artisans such as carpenters and blacksmiths (Sanderson & Sanderson, 1981). Sanderson and Sanderson (1981) explained that the colonial policy provided limited education to local citizens and discouraged rapid expansion of education; as a result, in 1910 Southern Sudan had only 200 students enrolled in formal schools.

According to some scholars, the limited focus on science education in Sudan, as well as in Nigeria, contributed to economic deterioration of both countries after they
achieved independence (e.g., Okonjo, 2000). These scholars argued that the lack of a skilled labor force and the limited numbers of industries owned and operated by indigenous people contributed to this deterioration. Notably, scholars blamed colonial schools in Sudan and in many parts of Sub-Saharan Africa for their failure to promote critical thinking and intellectual engagement with the sciences. They maintained that inadequate science preparation among the populace impeded post-colonial industrialization in these parts of Africa (Sanderson & Sanderson, 1981).

According to some commentators, colonial governments neglected not only science education but also education in other academic disciplines (Sharkey, 2003). Instead, they emphasized the acculturation of students to the norms, values, and practices of the colonial regimes in power (Sharkey, 2003). In Sudan, where Britain was the colonial power, a British model of schooling was put into place to produce graduates who would be able to speak English and behave and dress in the British fashion. As was the case in other states in Sub-Saharan Africa, however, schools in Sudan did not measure up to their colonial counterparts in terms of teacher quality, professional development, facilities, textbooks, or curriculum (Sharkey, 2003). Obanya (1999) referred to the differential between schools in colonial Africa and those in Britain as the “knowledge gap” because schools in Sudan (as well as in other African nations) lagged behind those in Britain (and other European colonial powers) in terms of curriculum and pedagogy. One result of this system was that Sudanese graduates of schools that focused on academics were inferior to British graduates in terms of their mastery of academic knowledge. Technical schools in Sudan and other African countries were similarly disadvantaged and, as a consequence, produced substandard results.
Moreover, enrollment of female students was limited, and in many African states education was reserved for a small class of privileged males (Egbo, 2000). For this reason, according to Mazrui (1986), colonization moved African states toward Westernization without providing them with the specialized human capital and economic prosperity supposedly associated with modernity. Indeed, as several commentators have suggested, colonization seems to have produced quasi-modern states that lacked the technical skills and expertise to be economically viable and self-governing (Obanya, 1999; Sunal et al., 1998).

Between 1950 and 1960, many African states sought to improve their performance in scientific fields as a way to promote economic development (Mutua & Sunal, 2004; Obanya, 1999). Schools were supposed to produce qualified graduates in the sciences in order to improve local industries that would in turn produce goods and services to reduce dependency on imports and lead African states toward self-reliance (Nyerere, 1972; Obanya, 1999; Sunal et al., 1998). Instead, as some historians have argued, the educational infrastructure deteriorated and industrialization took several steps backward—conditions that limited the possibility for many states in Sub-Saharan Africa to achieve economic sufficiency (Obanya, 1999; Serageldin, 1990).

Following independence in 1956, Sudanese schools, like schools in many newly independent African states, continued to operate on the British model, but their quality was poor (Obanya, 1999). Graduates of these schools were not sufficiently competent to assume roles as leaders, innovators, or entrepreneurs and thereby to realize the nation’s post-independence aspirations for economic development, particularly through the development of indigenous enterprises (Nyerere, 1972; Sunal et al., 1998). In addition,
attempts to base improvement initiatives in Sub-Saharan Africa on Western economic theories did not yield the desired results (Okwach & Abagi, 2005).

Nevertheless, following the colonial era in which education had been closely circumscribed and tied almost exclusively to the needs of the colonizers, the first decades after independence represented a period in which nations increased the amount of education offered to the citizenry (Obanya, 1999). Government leaders hoped that increased school enrollments would contribute positively to nation building and economic development (Sunal et al., 1998). These hopes were not fulfilled, however. According to some scholars, disappointing outcomes in nations such as Sudan can be attributed to corruption, party rivalry, and ethnic violence (Obanya, 1999; Okonjo, 2000).

Obanya (1999), for example, explained that, after initial improvements, educational services deteriorated in both quality and quantity because of limited resources, irrelevant curricula, poorly trained teachers, and other problems. He pointed to the prevalence of “descolarisation” in many schools, a word he coined to describe the general sense of apathy toward schooling in many African countries. According to Obanya, many people viewed education as irrelevant to the creation of employment opportunities and to national needs for economic growth. Furthermore, Obanya noted that education in Africa suffered in response to a variety of political and economic problems including political instability, unfavorable international trade, on-going internal conflicts, population growth, environmental degradation, and decreasing economic prosperity (Obanya, 1999).

In addition, Sudan’s indebtedness to the International Monetary Fund and the World Bank, a problem common in African states, further exacerbated the poor condition
of many schools (Obanya, 1999). In response to the requirements of these lenders, governments cut back large numbers of civil servants and teachers. This situation negatively affected schools, limiting the duration of students’ enrollment and the quality of the education (including the science education) offered to them (Federal Research Division of the Library of Congress, 1998). As a result, schools did not produce graduates with marketable skills, and many students who dropped out remained unemployed because of stagnant national and regional economies (Obanya, 1999).


Another call for educational reform came from a summit meeting, which was held in Tanzania. Participants of the summit concluded that science education would resolve the common problems that African states faced: environmental degradation, high rates of pollution, population growth, high AIDS/HIV infection rates, and high mortality rates (Sunal et al., 1998). Other pressing issues for which reform of science education was seen as a partial solution included the need to settle Africa’s debts to international lenders and
the need to improve the management of natural resources (Mutua & Sunal, 2004). Furthermore, according to some scholars, recent concerns about environmental degradation in Sudan and other African states has resulted in the expansion of the science curriculum in some nations to include environmental science (Sunal et al., 1998).

Despite numerous calls for improvement in science education, little has changed. In fact, according to some commentators, the knowledge gap has actually widened (Obanya, 1999). Petterson (2003) explained this circumstance in terms of Sudan’s poor infrastructure, high incidence of common diseases, and shortage of qualified medical doctors, substandard health services, and frequent power outages. Thus, even though the intention has been to improve science education, the quality of performance in scientific fields has remained low (Federal Research Division of the Library of Congress, 1998).

**On-going Calls for Reform in Africa and Around the World**

Educators and policy makers in African nations as well as in numerous other nations around the world still believe that reforms are needed. Seymour and Hewitt (1997), for example, reiterated the need for reform in science education. They claimed that, in the 21st century, national economic anxiety and international competition for economic prosperity would likely fuel science education reform, not only in developing nations, but also in the United States.

One international comparative analysis (Becker, 2002) showed the importance of building human capital in science in both developed and developing nations and encouraged developing nations to invest in science. Becker claimed that by building human capital, especially in science, nations could stimulate technological changes. According to his analysis, without major global improvements in human capital, richer
countries would continue to be dominant in the knowledge-based economy, and
developing countries would continue to fall behind, relying on the production capacity of
low-skilled labor. Becker’s analysis supported the call for developing nations to reform
science education as a means to increase their participation in the knowledge-based
economy, stimulate economic growth, and thereby alleviate poverty.

A similar perspective was put forth in a proposal from the Emirates Center for
Strategic Studies and Research (1999). According to this proposal, a country’s survival in
the 21st century would depend to a great extent on industrialization and information-based
applications of science. With this in mind, the proposal claimed that education reform
policies should aim to close the knowledge gap in order to prevent inequities among
nations that might lead to global polarization and political instability.

As suggested in the discussion above, the Sudanese government as well as many
governments in Sub-Saharan Africa recognized the importance of science education as a
means to accomplish national economic goals. Nevertheless, actual reform of science
education has remained elusive. Although there have been and continue to be many
different impediments to the reform of science education in Africa, one important
constraint relates to the academic choices that African students have been making
(Federal Research Division of the Library of Congress, 1998). In particular, a large
proportion of students tend to study liberal art disciplines rather than science disciplines
(Federal Research Division of the Library of Congress, 1998; Sunal et al., 1998). This
circumstance perhaps suggests that many African students hold negative attitudes toward
science and the study of science.
Several recent studies have addressed this issue. A study conducted by the United Nations Development Program (2005) that focused on science education in Arab states found that factors leading to students’ disenchantment with science education included poor recruitment efforts, inadequate academic support, inadequate teaching and academic assessment, lack of sufficient numbers of qualified staff, inadequate library resources, and limited internet access.

In another study, this one conducted in the United States, Seymour and Hewitt (1997) investigated attrition among science students. Their findings disclosed many factors that seemed to influence students’ choices. They found that socioeconomic status as well as minority status contributed to high attrition rates. They also found that inadequate teaching, difficult or confusing material, loss of confidence, high competition, a system focused on weeding out students, dull subject matter, and an ineffective grading system kept students from continuing their studies in the sciences. The author of this dissertation found Seymour and Hewitt’s research to be exemplary in that it incorporated many variables with the potential to affect attrition, and it appeared suitable for replication especially in Sudan, where empirical research in schools and classrooms is relatively rare.

A team of researchers studying science education reform in Rwanda (Earnest & Treagust, 2004) reported several dilemmas related to science education in that country. Their research, based on qualitative studies of 20 teachers, revealed that science teachers in Rwanda received lower pay compared with their colleagues in other occupations. They also had access to inadequate laboratory facilities, adhered to an outdated national science curriculum, used ineffective methods for teaching and for assessing students’
work, worked with inadequate materials, and had limited opportunities for professional development.

Another problem with science education in Africa has been the practice of teaching science in a foreign “language of instruction” rather than in students’ native languages. In an ethnographic case study focusing on science instruction in Benin, the use of a “language of instruction” rather than the students’ native language appeared to interfere with students’ learning of science (Simonis & Dado, 2004). The study identified several common problems: (1) students misunderstood inquiry procedures, (2) they mispronounced scientific terms and were unable to explain some terms, (3) students were unable to work independently, and (4) they were confused by the use of both the official language of instruction and the local languages. In addition, teachers had difficulty monitoring students’ learning and ensuring that students acquired knowledge of scientific concepts and terminology. The study’s findings also suggested that students in multilingual countries tend to have difficulties in grasping science terminology and concepts. These findings underscored Okonjo’s (2000) claim that the use of many languages posed pedagogical difficulties in Nigeria, a country that, like Sudan, hosts diverse ethnic groups all speaking different languages (Federal Research Division of the Library of Congress, 1998). Okonjo concluded that in Nigeria many students struggle with the expectation that they learn at least two languages, one for communication with members of their families and communities and the other for official communication in schools and government offices.

Summary
In summary, the discussion above indicated that, after their independence in the 1950s and 1960s, many countries in Sub-Saharan Africa, including Sudan, realized the importance of science education as a means to accomplish national scientific and technological goals so as to enhance industrialization and economic progress. The dream of these governments to accomplish national goals through industrial development, however, was not realized—a circumstance that adversely affected economic development. One of the primary reasons for limited industrial development and economic progress was reportedly the lack of human capital in fields such as science and technology (Sunal et al., 1998). Recent research, moreover, has identified some conditions that seem to be influencing human capital production in Sub-Saharan Africa. These conditions include unfavorable attitudes among students toward science education, inadequate school facilities, and ineffective pedagogy (Okonjo, 2000; Osborne, Simon, & Collins, 2003).

In many nations internal and external factors have impeded economic development—a circumstance supporting some commentators’ calls for accelerated growth in the field of science. Colonial legacies and inappropriate education systems adapted along the lines of the colonial systems (even after the independence of African countries) have contributed to the poor state of industrialization in many African states including Sudan (Obanya, 1999). In particular, the education systems adapted from the former colonies did not produce the desired number of graduates in science and technology to enable these countries to achieve goals related to industrialization and economic progress (Beshir, 1969; Federal Research Division of the Library of Congress, 1998; Sanderson & Sanderson, 1981). Therefore, according to several analysts, African
states, including Sudan, still need to reform science education in ways that contribute to the production of a sufficient number of scientifically trained workers (Earnest & Treagust, 2004; Obanya, 1999; Okonjo, 2000).

Many scholars have pointed out that both the number of secondary students and these students’ choices to study arts and humanities subjects rather than science subjects profoundly affect the number of graduates in science and therefore the scientific knowledge base in African nations (Mutua & Sunal, 2004; Okwach & Abagi, 2005; Okonjo, 2000; Obanya, 1999; Sunal et al., 1998). Moreover, recent trends indicate that disenchantment with schooling and poor attitudes among many students have further diminished the number of students enrolling in science majors (Jenkins & Nelson, 2005; Osborne, Simon & Collins, 2003; Seymour & Hewitt, 1997). Sudan, for example, offers two options to students in secondary schools—either major in science subjects or major in arts and humanity subjects. According to the Federal Research Division of the Library of Congress (1998), students have tended to favor arts and humanities subjects. Therefore, Sudan has disproportionately fewer graduates in the sciences than in the arts and humanities.

To explore why students in Sudan disproportionately select arts and humanities majors over science majors, this study intends to investigate the role of attitudes on first-year senior-secondary-school students’ intended choices of majors. Because gender, socioeconomic status, and parents’ and peers’ influences may also affect students’ educational choices, these variables are taken into account in this investigation.

*Theoretical Framework*
This study focuses on students’ choices, and, like many similar studies, it is grounded in a theory of cognition and behavior—in this case the theory of reasoned action (TRA). This theory suggests that a person’s behavior is determined by his or her intention to perform the behavior, which is a function of his or her attitude towards the behavior as well as subjective norms associated with the behavior (Ajzen & Fishbein, 1980; Ajzen & Fishbein, 1975). In other words, TRA explains behavior using three general constructs: behavioral intention, attitude, and subjective norms. According to the theory, behavioral intention (BI) is a function of attitude toward the behavior (AB) and subjective norms (SN) regarding the behavior. In this formulation, subjective norms stand for individuals’ perceptions of the cultural expectations and understandings that define and regulate a particular behavior.

Whereas some theorists have explained action in qualitative terms, Hale, Householder, and Greene, (2002), by contrast, indicated that the relationship among the three fundamental constructs of TRA can be understood in the form of the mathematical function: BI = (AB) W1 + (SN) W2. In which BI = behavioral intention, (AB) = student’s attitude towards performing the behavior—non-subjective norm, W = empirical derived weights, and (SN) = student’s subjective norm related to performing the behavior.

In the context of this study, the behavioral intentions of students toward the study of science depend on their beliefs, including their attitudes and their views about the attitudes of others, namely parents and peers. According to Ajzen and Fishbein (1975), in order to have a deeper understanding of behavioral intentions of students toward their education, it is necessary to assess both attitudinal and normative influences.
Despite its utility for explaining influences on behavior, TRA has some limitations. Notably, students’ ultimate behavior may not reflect their intentions. For example, a student may intend to choose a major in science but in the end choose a major in arts or humanities. Such behavior may result from irrational rather than rational processes, but not all apparent gaps between intention and behavior are actually irrational. Even with its limitations, however, TRA can help explain the connection between individuals’ mental processes and their eventual actions (Sheppard, Hartwick, & Warshaw, 1988).

The researcher considered TRA appropriate as a theoretical foundation for this study because it is both coherent and fairly well substantiated (Hale, Householder, & Greene, 2002). Moreover, the way the study is constructed provides a test of the theory. A student’s choice of a science major, on the one hand, or an arts or humanities major, on the other hand, represents his or her behavioral intention. In the model tested in this study predictors of behavioral intention include attitudes (endogenous attitudes in the TRA formulation) and parents’ and peers’ influence (exogenous subjective norms in the TRA formulation).

In summary, behavioral intention is a function of an individual’s attitudes and his or her perceptions of cultural norms. In this study, individuals’ attitudes toward science and their perceptions of cultural norms about the value of science combine to predict students’ behavioral intentions—to major in science or to major in something other than science.
Many Sudanese students in the past have shown greater interest in arts and humanities subjects than in science subjects, as indicated by their choice of major. In fact, one source reported that, since the 1980s, eight times as many students have entered arts or humanities majors as have entered science majors—a trend that has remained significantly unchanged over time (Federal Research Division of the Library of Congress, 1998). According to some commentators, moreover, students’ tendency to major in disciplines other than science has resulted in noticeable shortages of qualified personnel in the fields of science; and it has also contributed to economic underdevelopment (Petterson, 2003).

This study, therefore, sought to understand why secondary students in Sudan seem to be more likely to major in arts or humanities than in science. To gain information about these dynamics, the study investigated conditions and states of mind that influence the behavioral intentions of first-year secondary-school students when they contemplate the selection of a major. The researcher undertook this study in the hope that its findings would inform educators and policymakers who continue to look for ways to increase enrollment of students in science majors. Ultimately, the researcher believes, success with such efforts will improve the quality of science education and thereby promote economic development in Sudan.

The study considered several variables as potential influences on students’ intentions: their attitudes toward science, their perceptions of the norms of their peer group, the extent to which they value the norms of their peer group, their perception of the norms of their parents, the extent to which they value the norms of their parents, their
gender, and their socioeconomic status. The latter two variables, gender and socioeconomic status, were exogenous variables and were included in the study as controls. From the perspective of the researcher, the variable with the greatest potential to be influenced by educational policy and practice is attitude toward science. Parents’ and peers’ influences may also be amenable to change, but control over these conditions may be beyond the purview of schools. In other words, change in these conditions may depend on shifts in broader social policies and ultimately on changes in deeply held cultural norms.

The model tested in the study included students’ intention to major in science, on the one hand, or arts or humanities, on the other, as the dependent variable; it included attitudes toward science and the strength and direction of parents’ and peers’ influence as independent variables. It also included gender and socioeconomic status (SES) as independent control variables. In particular, the study addressed five research questions pertaining to first-year senior-secondary-school students’ choice of major:

1. What are the intentions of first-year senior-secondary-school students toward majors in science, on the one hand, or arts or humanities, on the other?
2. In consideration of the influence of gender and socioeconomic status, to what extent are students’ attitudes toward science associated with their choice of major (i.e., either a science major or an arts or humanities major)?
3. In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of parents’ influence associated with students’ choice of major?
4 In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of peers’ influence associated with students’ choice of major?

5 To what extent does the combination of variables—(a) students’ attitudes toward science, (b) the strength of parents’ influence, (c) the direction of parents’ influence, (d) the strength of peers’ influence, (e) the direction of peers’ influence, (f) gender, and (g) socioeconomic status—influence first-year senior-secondary-school students’ choice of major?

Significance of the Study

In the past three decades, many scholars in Sub-Saharan Africa have recognized and criticized the decline in the quantity and quality of education (Colclough, Al-Samarrai, Rose, & Tembon, 2003; Pendaefi, Ogunniyi, & Mosothwane, 1993; Sunal et al., 1998). Moreover, they have identified and expressed concern about the limited enrollment of students in science majors.

This study sought to investigate conditions that seem to influence enrollment in science majors in the hope that its results might inform national planners, scholars, and educators—helping them find ways to increase enrollment of students in sciences in secondary schools. For example, a similar study conducted by Seymour and Hewitt (1997) among university students in the United States found that, contrary to the assumption that decline in science enrollment was due to students’ lack of preparation for the challenges of studying science disciplines, other variables had a greater influence. These variables included students’ lack of interest in science, inadequate instruction, and problems with the curriculum.
Despite some evidence about U.S. students’ choice of science majors, few scholars (Mutua & Sunal, 2004; Sunal et al., 1998) have looked at factors that promote or impede science education in Africa. Substantial literature indicates that for education reforms to succeed, however, it is imperative to change current practices, values, attitudes, norms, and structures (Cuban, 1988; Hargreaves, 1994). Nevertheless, many researchers have pointed out that learning is situated within a specific socio-cultural context (e.g., Avraamidou, 2004; Barnett & Hodson, 2001; Borko & Putnam, 1994; Lave & Wenger, 1991; Wells, 1994). The development of curriculum in science should take into consideration specific and contextual knowledge about teachers’ experiences and methods of teaching as well as about students’ backgrounds, interests, and other characteristics (Barnett & Hodson, 2001; Lave & Wenger, 1991; Wells, 1994). From this perspective, many researchers argue that studies about students’ learning (including their attitudes toward learning) ought to provide the foundation for any type of educational reform (Seymour & Hewitt, 1997). Furthermore, in the absence of adequate information to guide educational policy in Sudan (Federal Research Division of the Library of Congress, 1998), this study will help policymakers make good decisions about how to direct resources in ways that encourage secondary-school students to pursue science majors.

In conclusion, this study will inform educators about possible ways to increase enrollment in science majors as opposed to arts and humanities majors at the secondary level. The aim of such efforts is to provide Sudan with adequate numbers of graduates with skills in science and technology to promote innovation and entrepreneurpship on behalf of economic development.
Chapter Summary

Chapter one provided background information relevant to and a rationale for a study of variables that influence Sudanese secondary-school students’ choice to major in science, on the one hand, or arts or humanities, on the both. The chapter included discussions of the following: (1) the relationship between scientific expertise and economic development, (2) a brief history of education in Sub-Saharan Africa, (3) ongoing calls for reform in Africa and around the world, (4) the theoretical basis (i.e., the Theory of Reasoned Action) for the model tested in the study, (5) the problem statement, and (6) the significance of the study.

In its consideration of the relationship between scientific expertise and economic development, the chapter discussed five salient theories— the structural-functionalist theory, modernization theory, human capital theory, dependency theory, and revitalization theory, particularly as these have been applied to circumstances in Sub-Saharan Africa. The most relevant theories to the study undertaken in the dissertation were human capital theory and revitalization theory.

The chapter also discussed pre-colonial, colonial, and post-colonial education in Sudan and other nations in Sub-Saharan Africa. It presented literature showing that colonial regimes created systems of education that, for the most part, prepared functionaries and manual laborers. The literature showed, moreover, that the legacy of these systems of schooling continued to limit educational opportunities and outcomes in nations such as Sudan even after they achieved independence.

As a result, calls for reform of education, including science education, persist. In Africa as well as in other parts of the world, policymakers continue to believe that reform
of science education is necessary in order to promote technological innovation, industrial
development, and global stability. Despite continuing efforts to make appropriate
educational reforms, however, students’ interest in science fields and their achievement
in science are still inadequate.

In order to explore such dynamics in Sudan, the researcher used the Theory of
Reasoned Action to propose a model that might explain secondary-school students’
choice to major in science, on the one hand, or arts or humanities, on the other. In
particular, the model proposed that students’ attitudes toward science, the strength and
direction of peers’ influence, and the strength and direction of parents’ influence would
predict their choice of major. The study examined these potential influences in
consideration of two salient exogenous variables, students’ gender and their socio-
economic status.

The chapter explained the significance of the study in terms of the potential for its
findings to assist Sudanese policymakers in identifying approaches that might serve to
increase students’ willingness to enroll in science majors. Of the variables included in the
model, the researcher argued that students’ attitudes might be the most amenable to
change via changes in schools’ policies and practices.
Chapter Two: Introduction to the Literature

Background

Chapter 2 offers a review of literature about students’ attitudes toward school science and their decisions about enrolling in science courses and majors. The first section provides an overview of the literature about scientific literacy and its historical basis. The second section defines “attitudes toward science” and introduces literature about the Relevance of Science Education (ROSE)—an instrument developed to gauge students’ attitudes. The third section describes what researchers know about students’ attitudes toward science education and their likelihood of enrolling in science courses and majors. It also examines extant research about the variables that have been shown to influence students’ attitudes toward science. In addition, this last section explains how the literature supports an investigation of Sudanese students’ attitudes toward science and decisions about enrolling in science courses and majors. Because literature about the attitudes toward science of students in Sub-Saharan Africa is scarce, this review relies on a wide range of relevant international literature.

The Quest for Scientific Literacy

A central issue in planning for scientific literacy has been the growing interest among educators to improve the quality and quantity of education in science (Jenkins & Nelson, 2005). Despite many attempts to increase scientific literacy, however, researchers believe little progress is possible until educators and policymakers reach agreement about the objectives of scientific literacy, the best ways to teach science, and methods for increasing the number of students who pursue studies of science disciplines (Osborne, Simon, & Collins, 2003).
As Laugksch (2000) noted, various groups continue to engage in debates about scientific literacy. These groups include science educators, social scientists, and policy analysts with particular interest in science and technology. An important point of contention is the extent to which scientific literacy should extend to the population as a whole or remain within the province of a small elite only.

A number of researchers have claimed that, as far back as the 16th century, science was restricted to a small group of scientists mostly from elite backgrounds; the public had little knowledge about science (Hurd, 1998; Laugksch, 2000; Oliver, Jackson, Chun, Kemp, Tippins, Leonard, Kang, & Rascoe, 2001). In fact, until the middle of the 20th century, scientific knowledge was limited to a small community of scientists who viewed their specialized knowledge as a source of power (Hurd, 1998). For example, in an 1847 lecture James Wilkinson mentioned that only 1% of the population benefited from scientific discoveries (Oliver et al., 2001). Moreover, in general, girls—even those from elite families—were far less likely than boys to study science (Oliver et al., 2001; Tolley, 1996).

Nevertheless, among a small segment of the elite, education in science was viewed as inappropriate for boys, whose education primarily centered around study of the classics (e.g., Latin, Greek, literature, philosophy, and so on). Interestingly, in some cases, young women from elite backgrounds received science education even when their male counterparts did not (Tolley, 1996). Nevertheless, the scientific education that some girls received in exclusive private academies consisted primarily of what Hurd (1997 citing Herbert Spencer, 1864) called “dead facts” (p. 25).
Attitudes toward science changed, however, in response to two popular reform movements, “Science for All” and “Scientific Literacy,” whose origins can be traced to the 19th century. “Science for All” was a campaign for wide dissemination of scientific knowledge to the public, while “Scientific Literacy” had similar objectives but focused primarily on the expansion of the study of science within the school curriculum (Hurd, 1997). To some extent these movements succeeded in changing the attitudes of scientists, educators, and the public. But several commentators have noted that, while these movements did expand public awareness of scientific discoveries, they did not produce deep understanding of science by large numbers of citizens (Millar & Osborne, 1998). In the 1950s, for instance, U.S. policymakers again voiced deep concerns about scientific literacy as they sought ways to counter the apparent Soviet threat to U.S. supremacy in the space race (Hurd, 1997).

Although the period 1957-1970 saw increased support for scientific literacy, no consensus about what scientific literacy involved had yet emerged (Laugksch, 2000). According to Laugksch (2000), educators in the decade between 1970 and 1980 produced multiple definitions and interpretations of scientific literacy, but they still did not reach consensus. Moreover, after the appearance of the famous report of the National Commission on Excellence in Education (“A Nation at Risk,” 1984), attention to scientific literacy again came to the forefront; in this case concern centered on the role of a scientifically literate populace in reversing America’s purported decline in global economic competitiveness (Atkin & Helms, 1993; Jenkins, 1992).

Despite continuing concern about the scientific literacy of the general public, commentators nevertheless acknowledged that science had made tremendous advances in
the 20th century (e.g., Hurd, 1998). Scientists had not only expanded scientific study by segmenting traditional disciplines, for instance, biology, chemistry, physics, and earth science, into separate specialties with their own terminologies and research practices, but they had also expanded this realm of inquiry by combining some traditional disciplines into hybrids such as biochemistry, biophysics, astrophysics, and biomedicine. Hurd argued, however, that these changes had little influence on what school curricula put forward as science education. School science, in his view, continued to focus on traditional disciplines, whose facts, terminologies, and methods were codified in various sets of standards (e.g., national standards in some countries, standards of professional organizations, state standards in the United States). This interpretation suggests that in the 20th century scientists’ views about what might constitute scientific literacy continued to differ from educators’ and policymakers’ views.

In the 21st century, concerns about the objectives of scientific literacy persist (Correia, Valle, Dazzani, & Infante-Malachias, 2010). Added to the list of what might be considered necessary scientific knowledge are topics that relate to global sustainability—knowledge that would enable scientifically literate citizens to help find solutions to problems resulting from worldwide trends such as the knowledge explosion, globalization, and deterioration of the ecosystem (Correia et al., 2010). Also necessary from the perspective of these authors is reform in science pedagogy to ensure that graduates have the scientific knowledge necessary to fill scientific and technological jobs in an increasingly complex and competitive labor market. They argue that reforms in schools’ science curricula are necessary because, in the past, school science was intended in part to prepare students for the job requirements of the industrial era. The job
requirements of the postindustrial era, by contrast, involve a more sophisticated understanding of science and its influence on the economy and the environment.

Summary

This section provided an overview of the efforts over time to promote scientific literacy among an increasingly broad segment of the populations of developed and developing nations. As the discussion showed, debates about scientific literacy continue to focus on the economic and social benefits of spreading greater knowledge about science among the populace of modern societies. Despite efforts to expand scientific literacy, commentators in the developed and developing worlds continue to believe that more extensive and sustained efforts are needed.

What are Attitudes toward Science?

For the past 30 years, many studies have focused on attitudes toward science, both as a concept tied to scientific literacy and as a distinct construct among the many constructs used to measure people’s attitudes (Simon, 2000; Osborne et al., 2003). According to Osborne and associates (2003), Klopfer (1971) was among the first to categorize affective behaviors (and related sets of affective behaviors) that were relevant to science education. These sets of affective behaviors included attitude toward science and scientists, acceptance of scientific inquiry as a method of processing information, adoption of scientific or skeptical dispositions, enjoyment of science and the experience of learning about the natural world, development of interest in science and science-related activities, and the development of interest in pursuing a career in science or a science-related field. Four years later, Gardner (1975) drew a clear distinction between “attitude toward science” and “scientific attitudes,” indicating that “scientific attitudes”
referred to perspectives on science in society while “attitudes toward science” referred to perspectives on school science. Klopfer’s and Gardner’s efforts to delineate attitudes with relevance to science and science education were critical steps in the development of instruments for measuring affective responses to this domain of human activity (Mueller, 1986).

Building on Klopfer and Gardner’s work, other researchers (e.g., Osborne et al., 2003) explained that “scientific attitudes” entailed a complex set of attributes related to knowing and understanding, questioning, searching for data and meaning, verifying inferences, respecting logic, and considering premises in light of empirical evidence. These researchers also distinguished between “scientific attitudes” of this sort and “attitudes toward science,” which, from their perspective, related to the feelings, beliefs and values about the impact of science on society and the role of scientists.

In addition to the important distinctions made between “scientific attitudes” and “attitudes toward science,” researchers such as Osborne and associates (2003) and Simon (2000) claimed that the construct “attitude toward science” is complex—not just a unitary mental attribute, but rather a multi-dimensional attribute comprised of several sub-constructs. According to these authors, the sub-constructs comprising “attitude toward science” include perceptions about science teachers, anxiety about science, enjoyment of science, beliefs about the value of science, self-esteem with regard to one’s performance as a student of science, views of one’s achievement in science, and fear of failure in science courses.

Mueller (1986) concurred with the view that many sub-constructs were likely to be associated with attitude toward science in various ways, and he was not convinced that
traditional instruments for measuring attitudes were sufficiently precise in distinguishing among beliefs, opinions, perspectives, and attitudes. He recommended the use of qualitative interviews rather than typical paper-and-pencil measures.

These perspectives suggest that the construct, “attitudes toward science” is elusive. As several authors have argued, attitudes are internal states that may or may not relate to a person’s behavior. Because of the elusiveness of attitudes, some theorists and researchers have sought ways to explain the connection between attitudes and actions. Some have claimed that the Theory of Reasoned Action (TRA) is helpful for explaining how internal mental states like attitudes can have some, but not always a determining, influence on actions.

Osborne and associates (2003), for example, explained that TRA is particularly useful because it shows the relationship among attitudes, subjective norms, intentions and behavior. The theory applies to many types of decisions, among them students’ decisions about studying science in school. According to the theory, intentions are a product of both attitudes and subjective norms, and intentions influence behavior. In other words, one’s intentions result from a combination of one’s own attitudes and one’s disposition toward the attitudes of others (i.e., subjective norms).

Although intentions are closer to behaviors than either attitudes or subjective norms, they are not the same thing as behaviors. A student, for example, may have the intention to major in science, for example, but at the last minute he or she might behave differently. This apparent inconsistency (i.e., where a behavior does not seem to match an intention) might result from the influence of other circumstances in the student’s life.
(e.g., his or her family finances, ability to stay in school for the length of time needed, or grades).

Summary

The distinctions and linkages among attitudes, dispositions, beliefs, opinions, and intentions provided social scientists with a fuller understanding of the complexity of the construct, “attitudes toward science.” Despite the complexity, however, some theorists and researchers also saw value in attempting to measure attitudes toward science, even if such attitudes were connected only partially to intentions and actions.

The Theory of Reasoned Action (TRA) provided these theorists and researchers with a basis for connecting attitudes to behaviors or actions with respect to the study of science, among other actions. According to this theory, attitudes and subjective norms (i.e., the disposition toward the attitudes and perspectives of others) influence intentions, which in turn influence behaviors. Several of these theorists and researchers recognized, however, that exogenous factors (e.g., financial resources) might also influence students’ actions. As this section of the chapter suggested, some science educators have used TRA to help predict conditions that might encourage students to enroll in science courses and majors.

ROSE and Students’ Attitudes

The possibility of improving schools’ science offerings and the science achievement of students has generated wide interest in recent decades. Spurring on this effort have been the international comparisons of achievement across various nations (Jenkins & Nelson, 2005). International assessments that enable such comparisons have
included the Third International Mathematics and Science Study (TIMSS) of 1995 and the Programme for International Student Assessment (PISA).

Whereas these earlier assessment programs focused primarily on achievement and, to some extent, on instructional practices, the Relevance of Science Education (ROSE) project focused on students’ attitudes toward, interest in, and extramural activities relating to science education. The ROSE project, in particular, drew attention to students’ voices and active participation in science education. The perspective of its sponsors has been that students’ active engagement in science promotes the learning of science and eventually contributes to high levels of science achievement (Jenkins & Nelson, 2005).

Despite nations’ efforts to improve science education through policies and programs that respond to international comparisons, students’ participation in high-level science courses still seems to be on the decline (Osborne et al., 2003). Some researchers (e.g., Osborne et al., 2003) attribute the decline to students’ unfavorable attitudes toward science. Their perspective is not new, however. Since as far back as the late 1960s, researchers have been exploring the link between attitudes toward science and enrollment in science courses and majors.

In the 1970s, for example, Ormerod and Duckworth (1975) studied students’ attitudes toward science and concluded that students’ lack of interest contributed to the declining number of students pursuing high-level course work in science. In the years that followed, other commentators (Gardner, 1975; Munby, 1983; Schibeci, 1984) continued to voice concern about reduced enrollment in science courses and majors (Jenkins, 1994). In response to findings from a recent study, Osborne and associates (2003) concluded that
students’ increasingly negative attitudes toward science posed a major threat to cultural
development, scientific literacy, and economic progress. These authors argued that, on
behalf of scientific literacy, the aim of school science should be to promote enthusiasm
for the study of science, to encourage students to pursue careers in science, and to
inculcate lifelong interest in science.

What do Researchers know about Students’ Attitude toward Science?

The literature on students’ attitudes toward science suggests that such attitudes
contribute to students’ decisions with regard to the study of science as well as to their
views of science as a human endeavor. Some research also shows that students’ attitudes
are responsive to instructional approaches and other explicit efforts to make science
interesting. At the same time some studies seem to show that the experience of school
science generally tends to dampen students’ interest in science.

The discussion below reviews the relevant empirical research in three categories:
(1) research examining the association between attitudes toward science and the study of
science, (2) research examining the association between attitudes toward science and
views about the importance of science, and (3) research investigating influences on
attitudes toward science. Although the discussion does not provide an exhaustive review
of these large bodies of literature, it does summarize the important themes that the
empirical research discloses.

Attitudes toward Science and the Study of Science

Several studies suggest that students’ attitudes play a role in predicting their
choices with regard to the study of science. In particular, negative attitudes toward
science, which students often attribute to the way science is taught in school, contribute
to decisions about enrollment in science courses (Osborne et al., 2003; Schreiner & Sjøberg, 2004).

Moreover, many empirical studies have found that students’ attitudes toward the study of science have become more negative since the middle of the 20th century. For instance, two studies from the United Kingdom (Osborne, Simon, and Collins, 2003) showed large declines in enrollment in science courses. The first study revealed a more than 13% decline in the percentage of secondary students who enrolled in science courses between 1980 and 1993. The second study showed a similar decline in the percentage of students taking A-level courses in science during roughly the same period of time. Both studies demonstrated that students were shifting away from the study of science by itself and were pursuing studies across a wider range of disciplines (e.g., science, math, humanities, and social sciences).

Similar findings have been reported by other researchers as well (e.g., Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000). Overall, this research suggests that students attribute their lack of interest in science to the irrelevance of the science curriculum, the need to memorize large numbers of definitions and facts in order to do well in science classes, and the perceived difficulty of studying science. Nonetheless, research has also shown that students’ growing dissatisfaction with the study of science is not equally distributed across science subjects (Ormerod & Duckworth, 1975; Ormerod, 1971; Osborn & Collins, 2000; Whitfield, 1980). According to some researchers, students tend to prefer biology to physics and chemistry because they see it as more relevant to their everyday life experiences (Lyons, 2006; Osborne & Collins, 2003).
Attitudes toward Science and Views about the Importance of Science

Rather than looking at how attitudes toward science relate to course taking, some studies have examined how such attitudes relate to students’ beliefs about the social importance of science. Many surveys, for example, have shown that students tend to be more positive about the contribution that science can make to society than they are about the value of studying science in school (Osborn et al., 2003).

Findings from an international study of science achievement in the middle-school years (Beaton, Martin, Mullis, Gonzalez, Smith, & Kelley, 1996) showed that 80% of students in Singapore, 90% in Thailand, 89% in Kuwait, 87% in Colombia, and 78% in the United Kingdom held positive views about science as a field of human endeavor. Nevertheless, their positive attitudes toward science in general did not predispose them to select science as the favored area of study. Two somewhat earlier studies had also reported similar results. First, Ebenezer and Zoller (1993) found that, out of the students in their sample, 73% believed school science was important, but 40% of these same students also expressed the view that school science was boring. In a larger survey (N = 1552) conducted in the United Kingdom by The Research Business (1994), 87% of students saw science as important in everyday life and 68% reported that science was useful, but only 58% reported that it was interesting, 53% reported that it was relevant, and 50% thought that it offered employment possibilities.

Some studies also have shown that students tend to report favorable attitudes toward science when they are asked questions about the value of science in contributing to technological advancement or to the betterment of humankind (Jenkins, 2006). Jenkins found, for example, that students expressed favorable perspectives toward science
because it eradicates diseases like HIV/AIDS and cancer and contributes to economic
development. But they also expressed negative views about science in relation to its role
in producing undesirable outcomes, such as increased poverty. These results are
consistent with findings reported by Osborne and Collins’ (2001) and Osborne and
associates (2003).

Influences on Attitudes

As suggested above, some studies have shown that the pedagogical practices used
by teachers seem to influence students’ attitudes toward the study of science. Other
research has revealed the association between students’ goals, motives, and personal
experiences and their attitudes toward science (Fazey & Fazey, 2001; Jenkins & Nelson,
2005; Lepper, 1988; Paulsen & Gentry, 1995; Suresh, 2007). In addition research has
pointed to effective teaching of science, gender, national reforms, parents’ and peers’
influences, and culture as conditions that seem to influence students’ attitudes toward
science (Mutua & Sunal, 2004; Obanya, 1999; Okonjo, 2000; Okwach & Abagi, 2005;
Osborne et al., 2003; Sunal, Jones & Okebukola, 1998). The discussion below briefly
summarizes findings from research examining these associations.

*Students’ experiences and characteristics.* As suggested above, some research
focuses on the associations between particular characteristics and experiences of students
and their attitudes toward science. For example, Glogowska, Young, and Lockyer (2007)
found that self-determination and commitment to pursue a profession in science
influenced students’ attitudes toward science. They also identified the influence of certain
experiences in students’ lives, including, among others, their need to hold a job, the
amount of time they have to devote to study, their health, and the amount of support they
receive from their families. Similarly, Suresh (2007) found that students’ behavior (including study habits, work habits, and coping strategies) and their motivation to succeed had significant effects on their attitudes toward and willingness to continue their studies of science. Although these studies showed that students’ personal experiences did have significant impact on their attitudes toward science education, effective teaching of science also seemed to play an important role.

*Effective teaching of science.* The quality of science teaching that students receive also influences their attitudes toward science. Some research, for example, has shown that ineffective science teaching tends to contribute to disenchantment and disengagement among students (e.g., Ango, 2000; Wilkins, 2002b). One commonly cited problem is the traditional style of teaching science that many teachers use. This style of teaching is common in Nigeria, for example, as Ango (2002) claimed:

The Nigerian context is one in which science teaching in primary and secondary schools all too often emphasizes rote learning without sufficient meaning and connections being made by students with their ordinary lives. Students often come away from science classes with a memorized set of definitions, but without a scientific attitude, without any appreciable expertise in scientific process skills and without any substantial ability to relate scientific concepts to their day-to-day lives. (p. 12)

Convinced that the current approach was unsatisfactory, Ango recommended reforming science teaching in ways that would involve students in more active exploration of the environment and greater engagement with the experimental method. Among other recommendations, she suggested that teachers provide instruction in skills
relating to observation, classification, manipulation, measurement, inquiry, organization, experimentation, and interpretation. In another study, Wilkins (2002b) also found that many teachers taught science in traditional ways, for example, by asking students to memorize sets of preexisting facts. He concluded that, if this approach to teaching science persisted, it would continue to promote negative attitudes toward science among students.

In a review of three studies conducted in Sweden, England, and Australia, respectively, Lyons (2006) identified ineffective teaching practice as a major cause of widespread deterioration of students’ attitudes toward science and declines in their enrollment in science courses. According to Lyons, the three qualitative studies (i.e., Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000), revealed that the teaching of school science tended to entail “the transmission of content from expert sources—teachers and texts—to relatively passive recipients” (p. 595). The three studies showed that students became disengaged from the study of science because the instruction they received mostly required them to memorize scientific concepts and facts rather than to engage in deep discussions or relevant inquiry. Lyons (2006) also found similar accounts in studies from the United States, India, and Korea.

**Gender.** According to Osborne and associates (2003), an extensive body of literature from the 1970s through the 1990s has shown that gender has a significant influence on students’ attitudes toward science. In particular, the literature revealed that boys tend to have more positive attitudes toward science and technology than girls do. Some researchers, moreover, have attributed the gender-based difference in attitudes toward science to children’s early socialization, suggesting that girls are given less
encouragement to tinker with technological devices and measurement instruments than boys are (Johnson, 1987; Jovanovic & King, 1998; Kahle & Lakes, 1983). As a result of these early experiences, many girls come to view science as a “masculine” subject and to feel excluded from studying it (Malone & Dekkers, 1989).

According to other researchers, girls also develop negative attitudes toward science because they fail to attribute their successes in science classes to their own abilities (Rosenthal, Guest, & Peccei, 1996). Downplaying their competence, they are less likely than boys to feel confident about pursuing more advanced science courses than those minimally required of them.

Some studies, however, have shown that more equitable teaching practices can help girls overcome their initial reluctance to study science (Jovanovich, Solano-Flores, & Shavelson, 1994). Miller, Lietz, and Kotte (2002), for example, found that efforts in the United Kingdom to improve girls’ attitudes toward science have resulted in decreases in gender disparities.

Nevertheless, such disparities persist in Sub-Sahara Africa, according to some researchers. For instance, a study that examined the experiences of 15 African women who were pursuing studies or careers in science revealed that both schools and workplaces tended to be inhospitable to females who were interested in science (Beoku-Betts, 2004). The researcher attributed such differential treatment to cultural norms, peer pressure, low expectations, social isolation, and biased employment policies. Lewis (2006) reached similar conclusions about gender disparities in Africa.

Related to the research in Africa, a study conducted in Israel showed that, in their initial years in school, girls and boys showed similar interest and academic achievement
in science (Ayalon, 2002). Later on in their school careers, however, boys began to take more advanced courses in science than girls and to achieve at higher levels. The researcher explained the findings in terms of the prevailing theories about why females have more negative attitudes toward and lower achievement in science than boys:

- Females often believe that science “belongs to” males (Tabar, 1992; Tobin & Fox, 1980).
- Many girls lack confidence in their ability to learn science (Adenkin-Morrow, 1996; Oakes, 1990).
- Teachers and administrators tend to hold stereotypical views about the abilities of female students (Maple & Stages, 1991).
- Few female role models give girls examples of how to succeed in science courses and careers (Oakes, 1990; Heller & Ziegler, 1996).
- Males frequently receive preferential treatment in the sciences (Burkan, Lee, & Smerdon, 1997; Hallinan & Sorensen, 1987).

*National reforms.* Across the globe, many nations have been trying to use legislation to foster improvements in science education in order to increase students’ scientific literacy as well as their interest and participation in science courses. Nevertheless, according to a number of researchers, such efforts have largely been unsuccessful in African nations (Mutua & Sunal, 2004; Obanya, 1999; Okonjo, 2000; Okwach & Abagi, 2005; Sunal, Jones, & Okebukola, 1998). These researchers reported that national reforms started to appear in the 1960s in many African nations, but that policymakers focused more attention on the political aspects of educational reform than on the curricular aspects. For example, in Sudan, many reforms in science education were
implemented by governments to fit with political agendas rather than to resolve problems in schools and classrooms (Federal Research Division of the Library of Congress, 1998; Lesch, 1998). Similarly, both Obanya (1999) and Okonjo (2000) claimed that political, social, economic, and cultural instability, coupled with corrupt political practices in many parts of Africa, has tended to limit the efficacy of educational reforms during the late 20th century. Moreover, even in recent years, few African governments have been collaborating with education scholars to initiate meaningful research programs directed toward raising public interest in scientific literacy and improving students’ attitudes toward science (Earnest & Treagust, 2004; Gado & Simonis, 2004; Kanga, 2004; Polakov-Suransky, 2004).

*Parents’ and peers’ influences.* In comparison to studies of the influence of gender on attitudes toward science and participation in science courses, far fewer studies have examined the extent to which (and ways in which) parents and peers influence students’ scientific literacy, attitudes toward science, and science course taking. Indeed, the researcher could find no studies of such relationships that had been conducted in Africa.

Some studies from the US and various other nations (e.g., Breakwell & Beardsell, 1992; Simpson & Oliver, 1990; Talton & Simpson, 1985), however, have shown the association between parent and peer influences and students’ attitudes. For instance, in a U.S. study Simpson and Oliver found some evidence of a relationship between parent support and their children’s attitudes toward science. In a study conducted in the United Kingdom, Breakwell and Beardsell (1992) found that mothers had more influence on students’ attitudes toward science than fathers did. These researchers also found that
mothers offered more encouragement to study science to their sons than they offered to their daughters. Wilkins and Ma (2002b), by contrast, did not discover a significant association between parents’ perspectives and students’ attitudes toward science, although they did find a significant association between parents’ perspectives and students’ views about the social importance of science.

Several studies also demonstrated the influence of peers on attitudes toward science. Wilkins and Ma (2002b) and Talton and Simpson (1985) in the US and Breakwell and Beardsell (1992) in the UK found that peer influence positively correlated with high-school students’ attitudes toward science.

Cultural factors. In addition to the influences discussed thus far, some studies have investigated the association between cultural influences and students’ attitudes toward science. Osborne and Collins (2001), for example, found that students tend to like studies of the science that their cultures view as acceptable and applicable to the practical life of communities.

Some research has also examined the influence of national culture (e.g., Hofstede, 2001) on students’ attitudes toward science and tendency to major in science fields. Jenkins and Nelson (2005), for example, reported that African students’ attitudes toward science were more positive than those of peers in developed nations. Considering this finding, we might see as ironic the fact that, in comparison to nations on other continents, African nations have the least number of scientists in proportion to the size of their populations (Osborne et al., 2003).

Other studies (e.g., Modood, 1993; Taylor, 1993) have produced findings suggesting that Asian students, as compared with their Western peers, tend to prefer to
study medicine, engineering, and mathematics; while Afro-Caribbean students tend to prefer to study disciplines in the social sciences. Finally, in a study of attitudes among African Americans on predominately White college campuses, Young (1983) discovered that many of these students selected arts and humanities majors because they believed that these fields had traditionally been open to minority students.

Chapter Summary

This chapter provided a review of the literature that supported an investigation of Sudanese students’ attitudes toward science and decisions about enrolling in science courses and majors. Because literature about students’ attitudes toward science in Sub-Saharan Africa is scarce, this review drew on a wide range of relevant international literature. It reviewed literature related to four issues: (1) the quest for scientific literacy, (2) the construct, “attitudes toward science,” (3) the ROSE as a measure of students’ attitudes toward science, and (4) generalizations from empirical research on attitudes toward science.

With respect to scientific literacy, the chapter reported that a central issue in educational planning has been the growing interest in improving the quality and quantity of instruction in science. Although this concern is not new, it has not thus far led to major changes in science education. As a result, the concern persists.

Students’ generally negative attitudes toward science seem to contribute to low levels of interest in studying science, and therefore to insufficient scientific literacy among the general public as well as insufficient numbers of scientists. Nevertheless, attitudes toward science are complex, and they do not always have a direct influence on
behavior. The Theory of Reasoned Action (TRA) helps explain the connections among attitudes, subjective norms, intentions, and behavior.

As the chapter explained, the researcher grounded the conception for the study in the Theory of Reasoned Action. To operationalize “attitudes toward science,” moreover, he selected an instrument known as the Relevance of Science Education (ROSE), which had been used in previous international studies. The chapter described research related to the instrument.

The final set of literature that the chapter discussed related to empirical findings about attitudes toward science. It summarized three rather substantial bodies of literature regarding (1) the association between attitudes toward science and the study of science, (2) the association between attitudes toward science and views about the importance of science, and (3) influences on attitudes toward science.
Chapter Three: Methodology

Introduction

In three sections chapter 3 describes the research methodology and methods used to guide the study. The first section describes the research design; the second section describes data collection procedures; and the final section describes data analysis, validity, and ethics of the study.

Research Design

Several writers (Gay, 1996; Moser & Kalton, 1989; O’Leary, 2004; Wiersma, 1995) define research design as a plan or strategy for conducting research. They explain that a good research design should enable a researcher to provide answers to research questions, but they also contend that the choice of a particular research design depends on the objectives and context of the study. The objectives and context also determine the research methodologies that are appropriate and the methodological steps that need to be taken. The methodological steps includes the definition of research questions and variables, the development of a sampling plan, the selection or development of instrumentation, data collection, data analysis, and interpretation of results. According to O’Leary (2004), research or methodological design includes the methodology, which is a set of paradigmatic assumptions; the method, which includes techniques for data collection; and the tools that help the researcher collect and analyze the data.

Choice of Research Design

The study involved a survey of secondary school students to investigate conditions associated with their intention to major in a science discipline, on the one hand, or an arts and humanities discipline, on the other. The independent variables of
interest in the study (i.e., the conditions potentially associated with choice of major) were
(1) attitudes toward science and (2) subjective norms as represented by the strength and
direction of parents’ and peers’ influence. Because gender and socioeconomic status had
been shown in earlier studies to be related to students’ selection of a major, they were
included in the analyses as control variables.

Studies of attitudes are common in social science. Such studies use many different
research designs, both qualitative and quantitative, depending on the research questions
and the conditions confronting particular investigators. Often researchers use
questionnaires to gauge participants’ attitudes (Mueller, 1986; Schreiner, 2006).

The researcher considered survey research to be a suitable design for the current
investigation because the research question focused on the attitudes and choices of
students in Sudanese schools, in general. The researcher was not interested in in-depth
responses from a few students but rather was seeking to make generalizations about the
broad population of Sudanese students. Also, because of financial constraints, time
limitations, and problems associated with the infrastructure in Sudan, survey research
allowed for investigation of a more or less representative sample of students. To conduct
the study under prevailing conditions, the researcher used a cross-sectional design, a type
of survey research that enabled him to collect data from a sample of students at one point
in time in order to explore relationships likely to characterize the population of Sudanese
high school students in general. Using the data obtained from the survey, the researcher
conducted statistical analyses that addressed the following five research questions:

- What are the intentions of first-year senior-secondary-school students toward
  majors in science, on the one hand, or arts or humanities, on the other?
• In consideration of the influence of gender and socioeconomic status, to what extent are students’ attitudes toward science associated with their choice of major (i.e., either a science major or an arts or humanities major)?

• In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of parents’ influence associated with students’ choice of major?

• In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of peers’ influence associated with students’ choice of major?

• To what extent does the combination of variables—(a) students’ attitudes toward science, (b) the strength of parents’ influence, (c) the direction of parents’ influence, (d) the strength of peers’ influence, (e) the direction of peers’ influence, (f) gender, and (g) socioeconomic status—influence first-year senior-secondary-school students’ choice of major?

Definition of Research Questions and Variables

For the purpose of this study, “science major” referred to a curriculum focusing on the study of biology, physics, and/or chemistry. In addition because of the close relationship between pure and applied science, a curriculum with an emphasis on technology or environmental studies was also considered to be a science major (Schreiner & SjØberg, 2004). Furthermore, a curriculum focusing on mathematics was also considered to be a science major. Students indicated their decision to select either a science or an arts and humanities major by their answers to a survey question about their
choice of major. Students’ answers about their choice of major represented the dichotomous dependent variable used in the study.

In this study attitude toward science, the strength of parents’ influence, the direction of parents’ influence, the strength of peers’ influence, and the direction of peers’ influence were the independent variables of interest. Gender and socioeconomic status were included as control variables.

The study measured attitude toward science using items from a well-established instrument, the ROSE. In addition, the questionnaire used in the study included Likert-type items asking about the strength and direction of peers’ and parents’ influence on students. It also included items asking students to self-report their gender and the number of books in their homes—an item used to gauge their socioeconomic status (SES). The researcher selected this method of measuring SES because this method had previously been used in the ROSE study. Additional details regarding instrumentation are provided below.

*Population, Sampling Frame, and Sample Selection*

The researcher was interested in the population of first-year secondary school students in Sudan, but in order to select a random sample of these students, he found it necessary to use secondary schools as the sampling frame. In addition, because schools in Khartoum were accessible and other schools were not, he included only these schools in the sampling frame.

*Sample Selection*
The study used a cluster sample of secondary schools, selected randomly from all secondary schools in Khartoum. The researcher chose to use cluster sampling for two reasons. First, schools were the only available sampling frame for identifying secondary school students. Even though secondary education in Sudan is centralized, the Sudanese Ministry of Education did not keep a roster listing all students in secondary schools. Individual secondary schools, however, did keep rosters of their students. Second, the researcher conducted the study under certain constraints, and therefore he could not devote much time or resources to negotiations that might have made alternative methods of sampling possible.

Nevertheless, one significant problem with cluster sampling in general as well as in the case of this study in particular concerns the degree to which a random sample at the cluster level actually produces a random sample at the individual (in this case, student) level (Moser & Kalton, 1989). A cluster sample, then, is more likely than a simple random sample to incorporate systematic bias. This threat, however, may have been less of a problem in Sudan than it would have been for a study in the United States because all secondary schools in Sudan are centralized, with students from a cross-section of the population enrolled in each.

The choice of secondary schools in Khartoum only and not those in other parts of the country—a decision that was made primarily in response to resource limitations—also reflected two assumptions. The first was that the ethnic composition of the population of Khartoum would roughly match that of the nation’s population as a whole. The researcher assumed, therefore, that a sample drawn from schools in Khartoum would tend to represent students from diverse ethnic and cultural backgrounds. Second, because
education in Sudan is centralized, the researcher assumed that the science curriculum and pedagogy in secondary schools would be similar across schools.

Sample Size and Sampling Method

In order to draw a sufficiently large sample to produce generalizable findings, the researcher needed a way to determine how large a sample to use. After considering approaches that had been recommended by various researchers (Gay, 1996; Kelley, 1999; Moser & Kalton, 1989; O’ Leary, 2004; Wiersma, 1995), he decided to adopt the “rule of thumb” that Gay (1996) recommended for drawing samples from large populations.

This choice was based on the researchers’ awareness that selecting an appropriately sized sample is not an easy matter. According to Kelley (1999) for example, the optimal sample size for a given study is not self-evident. In general, of course, researchers recognize that, with moderate-sized populations, inferences improve as the sample size approaches the size of the population. But with larger populations, such as the population of interest in this study, incremental increases in sample size beyond a certain threshold do not result in estimates that are much better than those that can be obtained with somewhat smaller samples. With all sample selection, however, the size of the sample that a researcher ought to poll depends on factors such as anticipated response rate, the number of variations within the population that the researcher believes are salient, the degree of error that the researcher is able to accept as reasonable, the researcher’s budget, and the amount of time the researcher has to spend in order to collect data (Kelley, 1999).

These considerations have led some researchers to conclude that, with large populations, sample sizes of 10% to 20% of the accessible population are sufficient (Gay,
Adopting Gay’s “rule of thumb,” therefore, the researcher decided to sample 20% of the target population for the current study.

The researcher could not, however, make the calculation in a simple manner because he could not obtain data about the number of students enrolled in all secondary schools in Khartoum. Nevertheless, he knew that approximately 50 secondary schools were located in Khartoum. On the assumption that each secondary school enrolled 100 first-year students, the researcher estimated that the population of first-year secondary students would be approximately 5,000. Using Gay’s rule of thumb, the researcher decided to select a sample that was 20% of the size of the population—in other words, 1000 students. Using a sample-size calculator, the researcher then found that a sample of 1000 would produce a sample with a confidence level of 95% and a confidence interval of 2.77 percentage points if the population size were indeed 5000.

For school (and therefore student) selection, the researcher generated a list of all schools for boys and another list of all schools for girls. He then organized each list alphabetically and assigned numbers (e.g., from 1-25) to them based on their position within the alphabetic sequence. To select five schools from each list, the researcher used the SPSS random number generator to select five integers. One list of random integers was used to identify schools from the alphabetical list of schools for boys, and another list of integers was used to identify schools from the alphabetical list of schools for girls.

Data Collection

This section describes the study’s approach to data collection. First it discusses the survey instrument used to collect data; then it reports on the procedures that the researcher used to elicit students’ responses to the survey instrument.
Instrumentation

The challenges associated with choosing the best instrument to measure attitudes toward science have been widely documented (Bennett, 2001; Gable & Wolf, 1993; Oppenheim, 1992; Osborne et al., 2003). Among the various internationally recognized instruments, such as those used in the Third International Mathematics and Science Study (TIMSS), the Programme for International Student Assessment (PISA), and the International Association for the Evaluation of Educational Achievement (IEA), the Relevance of Science Education (ROSE) is the most recent (Schreiner & Sjøberg, 2004). For this reason and also because the instrument’s developers encourage researchers to adopt or adapt it, the researcher decided to adapt it for use in the current study.

The team that developed the ROSE instrument included the director of the ROSE project, Professor Svein Sjøberg of the University of Oslo and several research partners from around the world (Schreiner & Sjøberg, 2004). This partnership was established in an effort to ensure that the ROSE instrument could be used with students in countries around the world.

The team that developed the ROSE instrument addressed a variety of technical and methodological issues associated with the constructs to be measured, the design of questionnaire items, pilot testing of the instrument, and test reliability and validity (Relevance of Science Education, 2004). Studies of the instrument have suggested that it has the qualities of a good research instrument, which include objectivity, reliability, validity, generalizability, and reproducibility (O’Leary, 2004). As a result of its technical adequacy, many researchers in developed and developing countries have administered the ROSE instrument to elicit information about students’ attitudes toward science and
perspectives about science education (Jenkins & Nelson, 2005). (See Appendix A5 for details).

The ROSE instrument consists of 250 items, most of which make use of four-point Likert-type response choices. The authors of the instrument grouped the items under ten sections (See appendix A6). Three of these sections explored students’ interest in learning various topics in science, namely space science, biological science, nuclear science, and animal science. Another section measured students’ priorities regarding the study of science and motivation to study science subjects, and yet another elicited information about students’ levels of empowerment to deal with the impact of science on the environment. In the sixth section of the instrument, questions focused on what students consider to be important, relevant, and interesting about science. In addition, the instrument included sections measuring students’ opinions about the importance and relevance of science and technology to society and students’ involvement with science and technology outside of school. The ROSE also included an open-ended question that asked students to discuss their career preferences and the reasons for their preferences as well as a question to determine the socioeconomic status of students’ families (Schreiner & Sjøberg, 2004).

The development of the study’s 28-item questionnaire. To construct the pilot version of the questionnaire for this study, the researcher selected 16 attitude items from the ROSE instrument. He also included four items relating to parents’ and peers’ influence as well as four items eliciting demographic information. The 16 attitude items selected from the ROSE focused on what students perceived to be relevant, important, and interesting in their science classes. Overall, the items concentrated on students’
perceptions about the pursuit of studies and careers in science rather than on their
knowledge of science or decisions regarding the study of science. The four demographic
items asked about students’ school, age, gender, and socioeconomic status. In total, the
20 items served as the study’s pilot questionnaire (See Appendix A1). Following analysis
of data from the pilot study, the researcher added eight more statements to the 20-item
questionnaire.

Pilot study. The researcher conducted a pilot study to test the 20-item instrument
(Maxwell, 2005). The pilot study involved 30 students from one secondary school. In
addition to seeking ways to improve the items on the instrument, the researcher also
wanted to see what difficulties students might confront in understanding the items, using
the Likert-type scale to respond to them, and completing the questionnaire in a reasonable
amount of time. A detailed description of the pilot study and an analysis of its findings
are provided in chapter four.

Modification of ROSE questionnaire items. Based on information obtained from
the pilot test, the researcher modified the wording of the response choices on the Likert-
type scale. In particular, he changed the wording of the points on the scale to read,
Strongly Disagree, Disagree, Agree, and Strongly Agree (See Appendix A2). The
modification was necessary as a way to improve clarity.

In addition, the researcher added eight items to the instrument. He added four
items relating to students’ attitudes toward science in order to improve the internal
consistency of the instrument. And he also added four other items to measure the strength
and direction of parents and peers’ influences on students’ choices about studying
science. The new items are listed below:
• I do not think I will use what I learn in math and science classes once I graduate from secondary school.
• In today’s world, studying math and science is more useful than studying other subjects like history and art.
• I plan to major in a science discipline rather than an arts or humanities discipline.
• Studying math and science will not help me very much in the career I would like to pursue.
• My friends prefer science fields over arts or humanities fields.
• I always chose what my friends recommend that I study.
• My parents would like me to pursue a career in scientific or technological field.
• I always listen to what my parents recommend that I study.

The final instrument consisted of 28-items: four demographic items, 20 items relating to students’ attitudes, and four items relating to peers’ and parents’ influences.

Administration of the Questionnaire

A representative of the researcher contacted the principals of the 10 secondary schools identified by the random process described above, and he asked the principals for permission to administer the final version of the questionnaire to all of the first-year students in each secondary school. Prior to administering the study’s questionnaire, the representative informed students that their participation was voluntary.

After the principal reported that the school’s set of questionnaires had been completed, the researcher’s representative in Sudan collected the questionnaires; photocopied each booklet; and sent the original to the researcher for coding, data entry, and data analysis.
Data Analysis

The researcher used the Statistical Package for the Social Sciences (SPSS) to analyze students’ responses to the questionnaire. The first step in data analysis was to compute descriptive statistics. The descriptive statistics used in this study included measures of central tendency and measures of dispersion (Kelley, 1999): frequencies, means, and standard deviations for each attitude item and for items measuring parents’ and peers’ influences and students’ socioeconomic status. In addition, the researcher used Cronbach’s Alpha to gauge the reliability of the instrument used to measure students’ attitudes toward science. In addition he calculated bi-variate correlations to identify the strength of the relationships between pairs of variables.

To test the models directly related to the study’s research questions, the researcher used logistic regression. The resulting equation predicted the influence of a set of independent variables (namely students’ attitudes toward science, the strength and direction of peer influence, the strength and direction of parents’ influence, gender, and socioeconomic status) on their choice of major in science, on the one hand or arts and humanities, on the other. This model also enabled the researcher to determine the relative strength of each of the independent variables that turned out to be a significant predictor of students’ choice of major. Logistic regression is a type of regression that researchers use to evaluate the separate and combined associations between various independent variables and a dichotomous or categorical outcome variable.

The researcher also used ordinary least squares (OLS) regression to evaluate a second model in which the focus was the association between a subset of the independent variables (namely, gender, SES, the strength and direction of peer influences, and the
strength and direction of parent influence) on students’ attitudes toward science, which in this equation was positioned as the dependent variable. This statistical method evaluates the separate and combined influences of a set of predictor variables on a particular continuous outcome variable. It depends on several assumptions: (1) that the relationships explained by the model are linear, (2) that the data come from a random sample, (3) that data for each case is independent from data for all other cases, (4) that the independent variables measure different constructs, and (5) that the distribution of error terms is random and that these error terms sum to zero. When these assumptions are met, OLS models provide several relevant outputs: (1) an R-squared value for each equation, which provides a measure of the degree to which the set of independent variables predicts the dependent variable, (2) Beta-weights for each predictor variable, which show the relative contribution of each independent variable to the prediction of the dependent variable in standard units of measure, and (3) model fit tests, which reveal the statistical significance of the observed associations.

Validity, Generalizability, and Limitations

Internal validity concerns the extent to which the independent variables included in the models tested in this study actually explain variance in the dependent variables. Because probabilistic models cannot support causal claims, internal validity rests on the careful selection of variables, the avoidance of multicollinearity, and the rigor of the survey administration procedures.

To assure that the variables included in the model represented a careful selection, the researcher conducted a thorough literature review. That review enabled him to base the selection of variables both on well-established theory (in this case, the Theory of
Reasoned Action) and on findings from earlier but related empirical research. These variables, moreover, focused on different kinds of potential influences—attitude, the direction and strength of parent and peer influence, gender, and SES. The likelihood that such disparate variables would introduce multicollinearity was minimal, as post-hoc diagnostic analyses confirmed. Finally, the researcher used rigorous procedures for selecting a random sample of respondents, administering the survey under controlled conditions, and assuring that students completed their own surveys without consulting with one another.

External validity concerns the extent to which findings from the study can be generalized to a population whose characteristics closely resemble those of the study’s sample. In this case, external validity would be assured if the study’s findings actually applied to first year secondary school students in Sudan. Although random cluster sampling provided some assurance of external validity, it is not as robust an approach as simple random sampling. Moreover, because all schools in the sample were in Khartoum, the likelihood that the study’s findings would apply to all senior secondary students in Sudan is questionable. At the very least, the study points to possible dynamics among senior secondary students in Khartoum with respect to conditions influencing their choice of science majors, on the one hand or arts or humanities majors, on the other.

Limitations and Delimitation of the Study

A study’s limitations include conditions that might compromise its internal validity. In this study, the fact that the models tested did not explain a great deal of the variance in the dependent variables suggests that other, unknown variables might be as influential or even more influential than the variables that the researcher decided to
include in the models. This situation represents the most serious threat to the study’s internal validity. Because the models tested in the study turned out to be less robust than the researcher had hoped, a cautious approach would be to treat the study’s findings as illustrative of possible dynamics and not as a definitive explanation of conditions influencing students’ choice of major. Indeed, the logistic regression model revealed that the factors included on the basis of the Theory of Reasoned Action were not as influential as the theory indicated that they would be.

The researcher delimited the study to a cluster of 10 secondary schools in Khartoum. As noted above, this choice compromised the external validity of the study. Its findings, therefore, cannot be viewed as generalizable to secondary schools located in rural Sudan or in other urban centers within the country.

Ethics of the Study

This section describes the ethics of the study including informed consent, confidentiality, consequences, protection of human subjects, and copyright exemption. 

*Informed Consent, Confidentiality, and Consequences*

Patton (2001) and Kvale (1996) contend that there are three ethical principles guiding research with human subjects, namely, informed consent, confidentiality, and consequences. Informed consent entails the procedures used to inform study participants about the purposes, main features, risks, benefits, and voluntary nature of participation in the study. Participants need to understand that they can choose not to participate in the study or ask to have their responses removed from the study’s data set. In this study, the researcher met the requirement for informed consent by following Ohio University’s policies for human subject protection.
According to Kvale (1996), confidentiality relates to the protection of private information about study participants. To assure confidentiality, the questionnaires did not contain students’ names or addresses. In addition data were presented only in aggregate form.

The consequences of research relate to possible harm or benefits to participants. As a general rule, the benefits of a study should far outweigh its costs to participants (e.g., Kvale, 1996). With a survey such as the one conducted in this study, potential harm to participants is quite unlikely. Few benefits also accrue directly to participants. Rather, the study benefits educational leaders and policy makers, whose decision making may be informed by the study’s findings. Improved educational practices that might result would then benefit students in the future.

The Institutional Review Board (IRB) of Ohio University has been charged with approving research designs that ensure human protection. Thus, IRB mandates submission of an application in advance of fieldwork. The author submitted an application to the IRB to seek fieldwork approval. The application, which was approved by the IRB detailed the purpose and design of research, description of the sample, and contents of the survey questionnaire.

Copyright Exemption

The instrument used in this study was adapted from the ROSE instrument—an instrument from a project intended in part to assist science and technology educators who are not directly involved with the ROSE project to conduct research related to the aims of the project. For this reason, the project leadership encourages science and technology educators to use the full ROSE instrument or adaptations of it for conducting research in
different countries and locales (Schreiner & Sjøberg, 2004). At the same time, the
ingredient that the researcher used in this study included only a small number of items
from the ROSE instrument. Even if the ROSE project staff did not encourage use and
adaptation of the instrument, this researchers’ selection of items would still conform to
the fair use guidelines outlined in U.S. copyright law. Applicable guidelines relate to the
educational purpose of the study, the nature of its publication, the amount of excerpted
material, and the fact that its use did not benefit the researcher materially not impinge
upon the earnings of the ROSE researchers. (See the following website for the applicable
guidelines: Albany College of Pharmacy and Health Services.

Chapter Summary

The first section of the chapter reviewed the research questions and described the
design of the study. The next section described the study’s population, sampling frame,
sample selection, sample size, and sampling method. Following this discussion, the
researcher described the data collection process including the development of the study’s
questionnaire and the collection of data from the sample of senior secondary students in
Khartoum. The researcher also explained the pilot study, its findings, and the way data
from the pilot study were used to improve the final version of the questionnaire. The last
sections of the chapter described data analysis procedures, limitations, delimitations, and
ethical issues related to the study.
Chapter Four: Findings

This chapter presents findings from a study of the relationship between selected characteristics of Sudanese high school students (including their attitudes toward science, age, socioeconomic status, responsiveness to parental influence, responsiveness to peer influence, and gender) and their choice to major either in science, on the one hand, or arts or humanities, on the other.

Data Analysis

This chapter begins with a brief description of data entry followed by the presentation of descriptive and inferential statistics. It concludes with a discussion of how the findings address the research questions that guided the study.

Data Entry

The researcher used Microsoft Excel for data entry and SPSS for subsequent data cleaning and data analysis. He coded students’ responses based on a four point Likert scale in the following sequence: one point for “Strongly disagree”, two points for “Disagree,” three points for “Agree,” and four points for “Strongly agree”. In order to sum items on the questionnaire that related to attitude toward science to produce one scale, the researcher coded responses to negatively worded questions in reverse order. The researcher then imported the data into the SPSS software package for data cleaning, coding, and analysis.

To clean the data, the researcher used frequency analysis as a way to identify possible errors of omission or misrepresentation in data entry; when he found errors in data entry, the researcher went back to the original questionnaire booklets and made
appropriate corrections to the data set in the SPSS file. In the process, he also omitted cases in which there were no responses to the items that measured the dependent variable.

He also created a variable for the global measure of attitude toward science by summing the 19 attitude items (1-19), and he created the final version of the dependent variable (i.e., plan to major in science) by converting the four choices for item 13 into a dichotomous (i.e., yes or no) dependent variable. The final set of independent variables were *Attitude toward science* (the sum of Items 1-19), *Peer influence 1* (i.e., the direction of peer influence), *Peer influence 2* (i.e., the strength of peer influence), *Parent influence 1* (i.e., the direction of parent influence), *Parent influence 2* (i.e., the strength of parent influence), *Books in home* (i.e., the proxy measure of SES), *Gender*, and *Age*. (See Appendix A3.) The final dependent variable was the dichotomous variable focusing on students’ plans to major in a science discipline on the one hand, or an arts or humanities discipline, on the other. The researcher used this final set of variables to compute the descriptive and inferential statistics.

*Technical Properties of the Instrument: Reliability*

Using the 19 items comprising the attitude scale, the researcher calculated Cronbach’s Alpha reliability. First, he computed Cronbach’s Alpha for all 19 items (as shown in Appendix A3) and obtained a reliability estimate of .65. He also conducted some exploratory analyses to see if the reliability might be improved by the removal of one or more items. He found that after deletion of just one item, item #8, the Cronbach’s Alpha for the remaining 18 items was slightly higher, .67. Both the first and the second computation of Cronbach’s Alpha (α) gave an approximate value close to .7, which is the minimum acceptable value of Cronbach’s Alpha recommended by Creswell (2003).
Nevertheless, the researcher realized that the scale’s reliability was certainly not robust and might contribute to an attenuation of the association between attitude toward science and the dependent variable, students’ choice of a science major, on the one hand, or an arts or humanities major, on the other.

**Descriptive Analyses**

The researcher examined frequencies for the three categorical independent variables—number of books in the home, gender, and age. For number of books in the home, about three-quarters (73.5%) of the students reported that their families had between no books and 50 books, and about one-tenth (9.2%) reported that they had no books; only about one-quarter (26.5%) of students had more than 50 books in their homes. This analysis suggested that the majority of parents did not possess large numbers of books and were, therefore, likely to have relatively low socioeconomic status. As discussed in chapter 3, “number of books in home” is a reasonable way to assess socioeconomic status.

In order to assure comparable numbers of male and female respondents, the study targeted voluntary participation of 1,000 participants from 10 secondary schools: 500 participants from five secondary schools for girls and another 500 from five secondary schools for boys. The results of the survey indicated that altogether from the 10 secondary schools that participated, 987 students responded, and 13 students did not respond to the questionnaire, providing a response rate of 98.7%. Among the respondents, 488 (49.4%) were girls, 495 (50.2%) were boys, and 4 (4%) were students who did not indicate their gender. Nonetheless, these findings showed that there was almost equal participation of males and females.
Similarly, the researcher examined the frequencies of students’ ages. About half of the students (51.5%) were aged between 12 and 16 years old, and the other half (48.5%) were aged between 17 and 40 years old, a finding suggesting that about 500 students had enrolled in secondary school at an age older than might have been expected. The enrollment of overage students may have resulted from (a) cultural practices such as retention of children at home for the purpose of performing domestic services, (b) lack of adequate school resources to serve all students eligible to attend, (c) lack of stability in schools during the period of time in which civil wars were taking place in Sudan, or (d) some combination of these conditions.

The researcher also calculated the means and standard deviations for each of the continuous independent variables. Table 1 presents the means and standard deviations of the 19 attitude items (without the statement representing the choice of a major) in a descending order. As demonstrated in Table 1, the first 15 items had means above the 3.0 point, while the last 4 items showed means below 3.0. The high means on most of these items suggest that the students, in general, either had quite positive attitudes about science or were responding to the questionnaire in ways that they thought would be acceptable to the researcher. The possibility that students’ ratings of their attitudes toward science were compromised by social desirability bias, therefore, needs to be acknowledged.

Despite the high means, however there was variability in responses to the 19 items comprising the attitude scale. The first four items showed the least variance, with standard deviations ranging between .8 and 1.2, whereas the last 12 items had greater variance, with standard deviations between 1.2 and 1.7. Despite some variability in the
responses to most items, students almost unanimously agreed with the statement, *Things that I learn in science at school will be helpful in my everyday life* (Item 2; SD = .8).

However, their responses to the statement, *I like school science better than most other subjects*, were the most varied (SD = 1.7).

Table 1

*Item Mean and Standard Deviation for attitude*

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude 4</td>
<td>School science has taught me how to take better care of my health.</td>
<td>3.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Attitude 11</td>
<td>School science has shown me the importance of science for our way of living</td>
<td>3.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Attitude 16</td>
<td>I think that the science I learn at school will improve my career chances.</td>
<td>3.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Attitude 2</td>
<td>The things that I learn in science at school will be helpful in my everyday life.</td>
<td>3.4</td>
<td>.8</td>
</tr>
<tr>
<td>Attitude 9</td>
<td>School science has increased my appreciation of nature.</td>
<td>3.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Attitude</td>
<td>Description</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>10</td>
<td>I would like to get a job in technology.</td>
<td>3.4</td>
<td>1.5</td>
</tr>
<tr>
<td>18</td>
<td>School science has opened my eyes to new and exciting jobs.</td>
<td>3.4</td>
<td>1.2</td>
</tr>
<tr>
<td>5</td>
<td>I would like to have as much science as possible at school.</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>6</td>
<td>School science has made me more willing to base judgement on evidence.</td>
<td>3.3</td>
<td>1.4</td>
</tr>
<tr>
<td>13</td>
<td>School science has increased my eagerness to learn about things we cannot yet explain.</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>7</td>
<td>I would like to become a scientist.</td>
<td>3.2</td>
<td>1.4</td>
</tr>
<tr>
<td>19</td>
<td>Studying math and science will not help me very much in the career I would like to pursue.</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>12</td>
<td>School science is interesting.</td>
<td>3.0</td>
<td>1.3</td>
</tr>
<tr>
<td>14</td>
<td>I like school science better than most other subjects.</td>
<td>3.0</td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td>In today’s world, studying math and science is more useful than studying other subjects like history and art.</td>
<td>3.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Table 1 (continued)

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude 17</td>
<td>School science is rather easy for me to learn.</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Attitude 1</td>
<td>I do not think I will use what I learn in math and science classes once I graduate from secondary school.</td>
<td>2.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Attitude 15</td>
<td>I think everybody should learn science at school.</td>
<td>2.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Attitude 8</td>
<td>School science is a difficult subject.</td>
<td>2.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

The researcher also calculated means and standard deviations for the four items measuring the direction and strength of parent and peer influences (see Table 2). Comparing the results, one notes that the students rated the influence of their parents as greater than the influence of their peers.
Table 2

*Item Mean for Parent and Peer Influences*

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent influence 1</td>
<td>My parents would like me to pursue a career in scientific or technological field.</td>
<td>3.4</td>
<td>1.3</td>
</tr>
<tr>
<td>(direction)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent influence 2</td>
<td>I always listen to what my parents recommend that I study.</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>(strength)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer influence 1</td>
<td>My friends prefer science fields over arts or humanities fields.</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>(direction)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer influence 2</td>
<td>I always chose what my friends recommend that I study.</td>
<td>2.6</td>
<td>1.5</td>
</tr>
<tr>
<td>(strength)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlations and Regression Analyses*

This section presents results from bi-variate correlations as well as the logistic regression model used to answer the research questions posed in this study.

*Bi-variate correlations*

The researcher computed Pearson product-moment correlations to examine associations among the independent variables of interest in this study. Table 3 reports these correlation coefficients.
The researcher noted that despite statistically significant correlations between many of the variables, in general the correlation coefficients were relatively small (ranging between .00 and .33). Kenny (1987) suggested that a correlation coefficient of .1 is small, a correlation coefficient of .3 is moderate and a correlation coefficient of .5 or greater is large. Thus, as shown in Table 3, there were moderate correlations between peer influence 1 (direction) and attitude, parent influence 1 (direction) and attitude, parent influence 2 (strength) and attitude, and parent influence 1 (direction) and parent influence 2 (strength).
Logistic Regression

The researcher then used a logistic regression model to compute the association between the independent variables and the dichotomous dependent variable—students’ decision to major in a science discipline. The analysis resulted in a statistically significant model that appeared to explain a limited amount of variance. The Cox and Snell R-square estimate was .135 and the Nagelkirke R-square estimate was .184. Table 4 shows the results of the logistic regression analysis.

Table 4

Logistic Regression Analysis for Variables Predicting Students’ Choice of Math/Science or Arts/Humanities Majors

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE B</th>
<th>Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer influence 1</td>
<td>.19</td>
<td>.07</td>
<td>1.21**</td>
</tr>
<tr>
<td>Attitude</td>
<td>.09</td>
<td>.01</td>
<td>1.10**</td>
</tr>
<tr>
<td>Peer influence 2</td>
<td>.10</td>
<td>.06</td>
<td>1.10</td>
</tr>
<tr>
<td>Parent influence 2</td>
<td>.07</td>
<td>.08</td>
<td>1.07</td>
</tr>
<tr>
<td>Books</td>
<td>.06</td>
<td>.05</td>
<td>1.06</td>
</tr>
<tr>
<td>Parent influence 1</td>
<td>.02</td>
<td>.06</td>
<td>1.02</td>
</tr>
<tr>
<td>Age</td>
<td>-.02</td>
<td>.02</td>
<td>.98</td>
</tr>
<tr>
<td>Gender</td>
<td>-.29</td>
<td>.13</td>
<td>.75*</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.15</td>
<td>.71</td>
<td>.01</td>
</tr>
</tbody>
</table>

*p < .05, two-tailed.  **p < .01, two-tailed.

The results indicated that peer influence 1 (direction) and attitude were positively associated with students’ reported choice to major in a science discipline, and that gender was negatively associated with their reported choice. The odds ratios—that is, Exp (B) in the Table—revealed that with other independent variables in the equation as controls (a)
peer influence 1 (i.e., the direction of peer influence) increased the odds of students’ majoring in a science discipline from 1:1 to 2.11:1, (b) attitude increased the odds of students majoring in a science discipline from 1:1 to 1.10:1, and (c) being a female decreased the odds of students majoring in a science discipline from 1:1 to .75:1. Of these odds ratios, the ratio for gender was stronger than the ratios for either peer 1 (i.e., direction) or attitude.

The association between gender and choice of a science major, however, held up only when other variables were in the equation serving as control variables. Chi-square analyses revealed no significant bi-variate association between gender and choice of major. The other two predictor variables continued to be associated with the choice of major whether or not control variables remained in the equation. The bi-variate Spearman rank correlation between attitude and choice of major was .32 (p ≤ .01), and the bi-variate Spearman rank correlation between peer 1 (direction) and choice of major was .19 (p ≤ .01). Table 4 further shows that peer influence 2 (strength), parent influence 1 (direction), parent influence 2 (strength), books in home, and age were not significantly associated with students’ reported choice to major in a science discipline.

In sum, this analysis suggests that among the eight independent variables, gender, peer influence 1 (direction), and attitude were useful predictors of students’ choice to major in a science discipline. The odds ratios, however, were not particularly strong. Also, as mentioned previously, the association between attitude and choice of major may have been attenuated because the scale lacked sufficient reliability.

Ancillary Analyses
To get a deeper understanding of the dynamics relating to students’ choice of a science major (rather than an arts or humanities major), the researcher used a regression equation to measure the association between the variable *attitude* (in this case positioned as a dependent variable) and independent variables, *peer 1* (direction), *peer 2* (strength), *parent 1* (direction), *parent 2* (strength), *books in home*, *age*, and *gender*. The equation was significant and had an R-square value of .23, suggesting that the independent variables explained variance in the dependent variable to a modest degree. Table 5 shows the association and the significance for each variable in the equation (listed in descending order of association).

Table 5

*Regression Coefficients and Significance*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer influence 1 (direction)</td>
<td>1.64</td>
<td>.20</td>
<td>.24**</td>
</tr>
<tr>
<td>Parent influence 1 (direction)</td>
<td>1.43</td>
<td>.21</td>
<td>.21**</td>
</tr>
<tr>
<td>Parent influence 2 (strength)</td>
<td>1.62</td>
<td>.25</td>
<td>.20**</td>
</tr>
<tr>
<td>Books in home</td>
<td>.47</td>
<td>.16</td>
<td>.09**</td>
</tr>
<tr>
<td>Peer influence 2 (strength)</td>
<td>.48</td>
<td>.19</td>
<td>.08**</td>
</tr>
<tr>
<td>Age</td>
<td>.02</td>
<td>.07</td>
<td>.01</td>
</tr>
<tr>
<td>Gender</td>
<td>-.01</td>
<td>.40</td>
<td>-.00</td>
</tr>
</tbody>
</table>

**p < .01, two-tailed.

The results show moderate positive associations between *attitudes* and *peer influence 1* (direction), *parent influence 1* (direction), and *parent influence 2* (strength);
and they show small positive associations between attitude and books in home and peer influence 2 (strength). With other variables in the equation, neither age nor gender functioned as a significant predictor of attitude.

In addition, the researcher regrouped students into two age bands (to assess the influence of students’ age—typical versus atypical high-school age—on attitude, peer influence, and parent influence. Among students (N = 974) who indicated their age, 72% (n = 702) were between 12 and 19 years of age, and 28% (n = 272) were 20 years of age or older. Using one way analysis of variance (ANOVA) the researcher found that group membership by age was unrelated to attitude $F(1, 947) = .032, p = .86$, the strength of parent influence $F(1, 972) = .49, p = .48$, the direction of parent influence $F(1, 972) = 1.46, p = .23$ or the strength of peer influence $F(1, 972) = .75, p = .38$ Age did have a significant association with direction of peer influence $F(1, 972) = 5.63, p = .02$. Whereas the mean for the younger students was 15.6 (SD = 1.60), the mean for the older students was 23.5 (SD = 3.33).

Answers to Research Questions

This section of the chapter shows how the analyses described above help provide answers to the research questions posed in this study.

*Research Question #1: What are the intentions of first-year senior-secondary-school students toward majors in science, on the one hand, or arts or humanities, on the other?*

The simplest way that the data analyses answer this research question is by showing the percent of first-year senior secondary students claiming that they plan to major in science in contrast to the arts or humanities. As the discussion above noted, 62.7
% of the students selected the response choice indicating that they planned to major in a science discipline. This percentage was much larger than the researcher anticipated. In fact, a major rationale for the study was the apparent lack of interest in science disciplines among senior secondary students in Sudan.

Consistent with the theory of reasoned action discussed in chapter one, the researcher also saw students’ attitude toward science as another indicator of their intentions to pursue studies in these disciplines. Table 1 (above) reports means and standard deviations based on students’ responses to the 19 attitude items. Inspection of the means and standard deviations indicates that students’ attitudes were between the labels of “agree” and “strongly agree” on the four-point Likert scales, suggesting that their attitudes were more than moderately favorable toward majors in science disciplines. Despite this result, students were close to neutral in their views about the difficulty of science subjects ($M = 2.5$, $SD = 1.6$), the ease of learning school science ($M = 2.8$, $SD = 1.4$), and the possibility of all students learning science at school ($M = 2.7$, $SD = 1.4$).

The theory of reasoned action also posited that subjective norms would play a role in determining students' intentions. As data presented in Table 6 show, students more than agreed ($M = 3.4$, $SD = 1.3$) with the statement that their parents would like them to pursue a career in scientific or technological field and also with the statement that they listened to what their parents recommended that they study ($M = 3.1$, $SD = 1.2$). However, students did not quite agree with the statement that their peers preferred science fields over arts or humanities fields ($M = 2.9$, $SD = 1.3$), and were almost neutral about the statement that they chose subjects of study that their friends recommended ($M = 2.6$, $SD = 1.5$). This analysis suggests that parents had more influence over students’
intentions to major in science disciplines than peers did, and also that parents preferred students to major in science disciplines. This interpretation, however, is not consistent with findings from the logistic regression which suggested that peer influence was more influential than parent influence on students’ decision to major in science. One possible explanation for the apparent inconsistency is that parents exert an influence on attitudes, which then exert an influence on students’ choices. When both parents’ influence and attitudes toward science are in the same equation, their shared variance may make it seem as if influence of parents is a trivial predictor. This possibility seems to be confirmed by the simplified regression model presented in Table 6. In this equation attitude toward science and age were omitted. When attitude toward science was the only variable removed from the equation, the contribution of parent influence 2 approached but did not reach significance.

Table 6

*Logistic Regression Analysis for Subset of Variables Predicting Students’ Choice of Math/Science or Arts/Humanities Majors*

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE B</th>
<th>Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-.25</td>
<td>.11</td>
<td>.78*</td>
</tr>
<tr>
<td>Books</td>
<td>.08</td>
<td>.04</td>
<td>1.09</td>
</tr>
<tr>
<td>Parent influence 2</td>
<td>.14</td>
<td>.07</td>
<td>1.15*</td>
</tr>
<tr>
<td>Parent influence 1</td>
<td>.12</td>
<td>.06</td>
<td>1.12</td>
</tr>
<tr>
<td>Peer influence 2</td>
<td>.10</td>
<td>.06</td>
<td>1.10</td>
</tr>
<tr>
<td>Peer influence 1</td>
<td>.02</td>
<td>.06</td>
<td>1.34</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.45</td>
<td>.33</td>
<td>.24</td>
</tr>
</tbody>
</table>

*p < .05, two-tailed
Research Question #2: In consideration of the influence of gender and socioeconomic status, to what extent are students’ attitudes toward science associated with their choice of major (i.e., either a science major or an arts or humanities major)?

The researcher examined the results of the logistic regression in Table 4 above to determine the extent to which students’ attitudes toward science were associated with their decision to major in science. The results showed that among the eight independent variables, attitude was a significant predictor, but not as strong as either gender or peer influence 1. Using Spearman’s rho rank-order correlation, the bivariate association between the two variables (i.e., attitude and choice of major) was .37 (p ≤ .001).

Research Question #3: In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of parents’ influence associated with students’ choice of major?

The researcher again examined the results of the logistic regression in Table 4 to determine the extent to which parents’ influence was associated with students’ choice of major. The results showed that neither parent influence 2 nor parent influence 1 was a significant predictor of students’ choice of major when all of the independent variables were included in the equation. Nevertheless, Spearman’s rho revealed significant, though small, bivariate associations between parent influence 1 and choice of a science major (r = .15, p ≤ .001) and between parent influence 2 and choice of a science major (r = .11, p ≤ .001). In addition, both parent influence 1 and parent influence 2 were predictors of attitude toward science (see Table 5). As suggested above, in the logistic regression model these variables may have had an indirect influence on students’ choice of major through their influence on students’ attitudes.
Research Question # 4: In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of peers’ influence associated with students’ choice of major?

Examination of the results of the logistic regression indicates that responses to the item asking whether or not peers preferred scientific fields over arts or humanities fields (i.e., peer influence 1) were positively associated with students’ choice of a science or math major. Responses to the item asking whether or not students listened to what peers recommended that they study (i.e., peer influence 2) were not significantly associated with students’ choice of a science major. Spearman’s rho rank-order correlations also revealed a significant bivariate association between peer influence 1 and choice of a science major \((r = .19, p \leq .001)\), and the bivariate correlation between peer influence 2 and choice of a science major was also significant \((r = .11, p \leq .001)\). In addition, both peer influence 1 and peer influence 2 were predictors of attitude toward science (see Table 5).

Research Question # 5: To what extent does the combination of variables—(a) students’ attitude toward science, (b) the strength of parents’ influence, (c) the direction of parents’ influence, (d) the strength of peers’ influence, and (e) the direction of peers’ influence, (f) gender, and (g) socioeconomic status—influence students’ choice of major?

In response to this question, the researcher considered students choice to major in science as the dependent variable and their attitudes toward science, parent influence 1, parent influence 2, peer influence 1, peer influence 2, gender, and socioeconomic status as independent variables. The results in Table 4 show that the combination of independent variables was significantly associated with students’ choice of major.
Nonetheless, as mentioned earlier, among the independent variables contributing to the overall association, *only peer influence 1, attitude toward science, and gender* were significant predictors of students’ choice to major in science rather than arts or humanities. Of the independent variables, gender was the strongest predictor of students’ choice of major.

**Summary of Findings**

This chapter presented findings from a study of the relationship between selected characteristics of Sudanese high school students (including their attitudes toward science, age, socioeconomic status, responsiveness to parental influence, responsiveness to peer influence, and gender) and their choice to major either in science on the one hand, or arts or humanities on the other.

The following represent the most important findings:

1. The instrument used to measure students’ attitudes toward science and mathematics was not highly reliable, perhaps contributing to an attenuation of the relationship between attitude toward science and mathematics and choice of a science major (rather than an arts or humanities major).

2. Far more students than the researcher had anticipated provided responses indicating that they planned to major in a science discipline rather than an arts or humanities discipline.

3. Students’ attitudes toward science were more favorable than the researcher anticipated based on findings from previous related studies. This result suggests the possibility of social desirability bias in students’ responses.
4. Three significant predictor variables contributed to a significant logistic regression equation in which *choice of science major* was the dependent variable: *gender* (negative association), *attitude toward science* (positive association), and *peer influence 1* (positive association). *Gender* was the strongest predictor.

5. Five significant predictor variables contributed to a significant multiple linear regression equation in which *attitude toward science* was the dependent variable: *peer influence 1* (positive association), *parent influence 1* (positive association), *parent influence 2* (positive association), *books in home* (positive association), and *peer influence 2* (positive association).
Chapter Five: Summary, Discussion, and Implications

This chapter contains a summary and discussion of the significant findings from a study of predictors of Sudanese secondary-school students’ reported interest in selecting a science major, on the one hand, or an arts or humanities major, on the other. It examines the findings in the context of the related literature as well as suggesting implications for practice and future research.

Discussion of the Study’s Major Findings

The study investigated possible influences on Sudanese secondary students’ choices of major fields of study by examining the association between eight predictor variables and the dichotomous dependent variable, choice of a science major, on the one hand, or an arts or humanities major, on the other. The eight predictor variables were: Attitude toward science, Peer influence 1 (i.e., the direction of peer influence), Peer influence 2 (i.e., the strength of peer influence), Parent influence 1(i.e., the direction of parent influence), Parent influence 2 (i.e., the strength of parent influence), Books in home, Gender, and Age. In order to accomplish the objectives of the study, the researcher arranged for secondary school students in Sudan to respond to a paper-and-pencil questionnaire. The researcher used descriptive statistics, logistic regression analysis, and multiple regression analysis to answer the five research questions that guided the study. The following is a summary and discussion of the main findings for each research question:

Research Question #1: What are the intentions of first-year senior secondary school students toward majors in science or humanities?
Calculation of frequencies revealed that 62.7% of students in the sample said they would choose a science major rather than an arts or humanities major. In addition, their responses to items measuring attitude toward science were mostly favorable. Respondents’ apparent interest in majoring in science differed from what the researcher originally had anticipated—namely low levels of enthusiasm for majoring in science—and it was also inconsistent with many findings from previous investigations showing that the study of science tends to be unpopular among students in Africa and in many other parts of the world. For example, Kennedy (1993) documented that fewer scientists held jobs in Sudan and other African states than held jobs in other countries around the world. Also in 1998 the Federal Research Division of the Library of Congress (Sunal et al., 1998) reported that students in general appeared to have negative attitudes toward science. Others (e.g., Jenkins & Nelson, 2005; Osborne, Simon & Collins, 2003; Seymour & Hewitt, 1997) found in the United Kingdom as well as in the United States that increasingly fewer students were enrolling in science majors than had enrolled in these majors in the past. The concern about negative attitudes of students toward science, which began 30-40 years ago (Osborne, Simon, & Collins, 2003), was also reflected in the late 1990s in Sudan, where about eight times as many students had enrolled in humanities and arts majors as had enrolled in science majors (Federal Research Division of the Library of Congress, 1998).

One explanation for the difference between findings from the current study and findings from previous studies is that many of the earlier studies reported on actual enrollments in science majors, and the current study reported on students’ espoused intention to enroll. Some research, however, has found that more students say that they
will major in science than actually do (Osborne et al., 2003). Similarly, Hendley, Stables, and Stables (1996) found that, based on the way questions about students’ preferences were asked, students appeared either to “love” science or to “hate” it. Whatever the case with respect to attitudes and intentions, most recent research (with the exception of outliers such as the present study) continues to report that dwindling numbers of students have been enrolling in science courses and majors (Jenkins & Nelson, 2005; Osborne et al., 2003; Schreiner & Sjøberg, 2004).

As noted above, however, most respondents in the present study reported that they were appreciative of science disciplines because of their relevance to students’ own health and welfare. In fact three statements relating to these themes received high ratings: “school science has taught me how to take better care of my health,” “I think that the science I learn at school will improve career chances”, and “the things I learn in science at school will be helpful in my everyday life.” These ratings fit with findings from a previous study in which students reported liking science and technology because these fields provided benefits to them personally and to their communities (Jenkins & Nelson, 2005).

Of particular relevance to the distinction between espoused beliefs, on the one hand, and actions on the other, was the finding in the current study showing that students’ ratings of their interest in school science was lower than their ratings of the relevance and practical value of science in general. In other words, students’ support for science disciplines—even the apparent support revealed by the high proportion of students who said that they would major in a science discipline—might have related more to students’ views that such disciplines have practical value than to their desire to study these
disciplines. This interpretation also seems to be supported by the finding that students generally saw science subjects as difficult. It is, after all, possible that students could find science difficult and relatively uninteresting but still recognize its value for their own career advancement, for personal health, and for the economic development of their communities.

Such dynamics might explain why the students who participated in this study tended to give higher ratings to science disciplines than were given by students in earlier studies (e.g., Jenkins & Nelson, 2005). In addition, this finding might fit with findings from previous studies reporting that the attitudes of students toward science in developing countries were more favorable than those of students in developed nations (e.g., Sjøberg, 2004). Perhaps the shortages of scientists and technicians in developing counties such as Sudan—and the associated career opportunities—motivate students to think about these areas of study even if they do not find them particularly interesting.

Another possible explanation is that students might associate science disciplines with economic progress because of the role these disciplines play in helping to provision communities with basic necessities (e.g., adequate and inexpensive food, health care, and so on). Many nations in Africa have acute needs for basic goods and services, and their citizens may be keenly aware of the contributions that scientists and technicians can make (Nyerere, 1972; Obanya, 1999; Sunal et al., 1998). These citizens may also recognize the role that professionals with expertise in science play in establishing new economic ventures (Obanya, 1999).
Research Question #2: In consideration of the influence of gender and socioeconomic status, to what extent are students’ attitudes toward science associated with their choice of major?

The logistic regression equation revealed that attitude was among the significant predictors of students’ intention to major in science rather than arts or humanities. In terms of the bi-variate correlation (Spearman’s rho rank-order correlation) the relationship between attitude toward science and students’ intention to major in science rather than arts or humanities was moderate. Its association with intended major, however, was attenuated when covariates were incorporated into the more fully specified logistic regression model.

In ancillary analyses, moreover, results showed that attitude had significant relationships with peer influence 1 (direction), parent influence 1 (direction), parent influence 2 (strength), books in home, and peer influence 2 (strength). Its shared variance with these other variables may provide an explanation for its relatively stronger association with choice of major in the bi-variate correlation and its relatively weaker association with choice of major in the logistic regression.

The findings related to students’ attitudes toward science were consistent with findings from previous research (Crawley & Coe, 1990; Koballa, 1988; Oliver & Simpson, 1988; Osborne, Simon, & Collins, 2003; Simon, 2000) and with the theory of reasoned action (Ajzen & Fishbein, 1980) that guided this study. In particular, these previous theorists and researchers posited (and also showed empirically) that attitudes toward science did not function independently from other related variables, such as parent and peer support, in determining either students’ intentions to major in science or
their actual behavior (i.e., choosing to major in science). Rather, in most studies, attitudes
toward science appeared to be influenced by parents’ and peers’ values as well as by the
degree to which students based their own preferences and choices on the values of their
parents and friends.

Research Question #3: In consideration of the influence of gender and socioeconomic
status, to what extent are the strength and direction of parents’ influence associated with
students’ choice of major?

As indicated in Chapter 4, the Spearman’s rho correlations showed significant,
but small bivariate associations between parent influence 1 (direction) and choice of a
science major and between parent influence 2 (strength) and choice of a science major.
In addition, the multiple regression analysis in which attitude was included as the
dependent variable suggested that parent influence 1 (direction) and parent influence 2
(strength) were significantly associated with attitude. The logistic regression equation,
however, indicated that, with other variables in the model, there was no significant
relationship between parents’ influence (either in direction or strength) and students’
choice of major.

One probable explanation for this apparent inconsistency (i.e., that parent
influence was associated with students’ attitudes but not their choices) is that the two
variables measuring parents’ influence may have been indirectly associated with choice
of major because of their direct association with attitude. When the two variables
measuring parent influence were included in the logistic regression model, their shared
variance with attitude made it seem as if they had no significant association with choice
of major. This interpretation makes sense in light of findings from many previous studies
showing that students’ attitudes toward science (as well as their performance in these subjects) are often influenced by parents’ attitudes, espoused preferences, and background characteristics (George, 2000; Keeves, 1975; Simpson & Oliver, 1990; Wilkins & Ma, 2002b; Woodrow, 1996).

Overall, these studies found that parent perspectives and involvement often influence students’ attitudes toward the study of science disciplines as well as their choices about taking courses in or majoring in these subjects (George, 2000; Keeves, 1975). Schibeci (1989) reported that mothers’ attitude toward science disciplines was associated with students’ interest in those disciplines. Similarly Talton and Simpson (1987) found that family attitudes toward science correlated with students’ interest in science.

Research Question # 4: In consideration of the influence of gender and socioeconomic status, to what extent are the strength and direction of peers’ influence associated with students’ choice of major?

The Spearman’s rho rank-order correlation indicated a small association between both peer influence 1 (direction) and peer influence 2 (strength) and students’ intention to major in science rather than arts or humanities. Nevertheless the logistic regression equation showed that only peer influence 1 (direction) was positively associated with students’ intention to choose a science. In that equation peer influence 2 (strength) was not a significant predictor.

As was the case with parent influence, the relationship of peer influence to students’ reported intention to choose a science major may have to some extent been indirect. The ordinary least squares (OLS) regression analysis tended to confirm this
interpretation by showing that both peer influence 1 (direction) and peer influence 2 (strength) had significant relationships with attitude.

These findings correspond to findings from previous studies (Fraser & Kelly, 2007; Kahle & Kelly, 2006; Keeves, 1975; Kobolla & Crawley, 1985; Simpson & Oliver, 1990; Talton & Sampson, 1985) reporting significant relationships between peer influence and students’ attitudes toward science. In addition, Kahle and Kelly (2006) and Fraser and Kelly (2007), in a study of influences of families and peers on students’ attitudes toward science, found that peer support was important, but that it represented a stronger influence for girls than for boys. Moreover, in other studies researchers have found that peers’ influence was more significant than either parents’ or teachers’ influences in shaping students’ decisions about majoring in science (Keeves, 1975; Kobolla & Crawley, 1985; Simpson & Oliver, 1990; Talton & Sampson, 1985; 1986). Similarly, in a study documenting changes in students’ attitudes toward and beliefs about mathematics, Wilkins and Ma (2002) found that peer influence was positively associated with students’ attitudes toward math. Although attitudes toward math and attitudes toward science are not identical, they are often related (Betz & Hachett, 1983; Lent & Brown, 1984). In another study—this one published quite recently—Rani (2006) found that peer influence had a small, but significant influence on students’ attitudes toward science.

In contrast to the findings of this study, a few earlier studies did not report positive associations between students’ attitudes toward science and those of the peers whose values they respected. For example, Atwater, Wiggins, and Gardner (1995) found that the friends of their respondents had less positive attitudes toward science than their
respondents did, and Schibeci (1989) found no effect of peer group influence on Australian eighth graders’ attitudes toward science. Nevertheless, despite these outliers, the majority of related studies did show that students’ attitudes toward science tended to reflect the attitudes of their peers.

Research Question # 5: To what extent does the combination of variables—(a) students’ attitude toward science, (b) the strength of parents’ influence, (c) the direction of parents’ influence, (d) the strength of peers’ influence, (e) the direction of peers’ influence, (f) gender, (g) socioeconomic status and (h) age—influence students’ choice of major?

In order of importance, the logistic regression model showed that gender, peer influence 1 (direction), and attitude were significant predictors of students’ intention to major in science rather than in arts or humanities. By contrast, the equation showed that parent influence 1 (direction), parent influence 2 (strength), peer influence 2 (strength), books in home (i.e., the study’s proxy measure of socioeconomic status), and age were not significant predictors of students’ choice to major in science rather than in arts or humanities.

These findings pointed to a narrower range of influential variables than had been reported in previous literature. Notably, some previous studies (e.g., Glogowska, Young, & Lockyer, 2007; Maxwell, 1997; Suresh, 2007; Woolnough, 1994) reported associations between choice of science major and parent influence, socioeconomic status, and age—three variables that in the current study turned out not to be significantly associated with intended choice of major. Some previous studies (e.g., Osborne et al., 2003; Simon, 2000), however, did reveal the influence of variables that, in the current study, also
showed significant associations with choice of major, namely gender, peer influence, and attitude. Some earlier studies also included variables (e.g., personality, school structure, and school curricula) that were not studied in this dissertation (e.g., Ango, 2002; Brown 1976; Hadden & Johnstone, 1983; Harvey & Edwards, 1980; Jenkins & Nelson, 2005; Johnson, 1987; Mukudi, 2004; Obanya, 1999; Okonjo, 2000; Osborne, Simon, & Collins, 2003; Simon, 2000; Simpson & Oliver, 1985; Tai, Sadler, & Mintzes, 2006; Wilkins & Ma, 2002a; Yager & Penick, 1986).

As mentioned previously, number of books in home was used as a proxy measure of students’ socioeconomic status (SES). Even though books in home was a significant predictor of attitude toward science, the results of the logistic regression suggested that books in home was not a significant predictor of students’ intention to major in science rather than in arts or humanities. This set of associations, like those observed for parent influence 1(direction) and parent influence 2(strength), suggests that books in home may have had an indirect influence on students’ choice of major through its influence on attitude.

In the current study age had no association either with students’ intention to major in science or with their attitude toward science —a finding that corresponds to some of what has been reported in previous related studies. Among previous studies, several reported negative associations or no associations at all, and a few studies reported positive associations between age and attitudes toward science. For instance, Ato and Wilkinson (1983), Chopin (1974), Hadden and Johnston (1983), Hofstein (1990), and Yager (1983) all reported increasingly negative attitudes toward science with increasing age. By contrast, Krajkovick (1978), Aiken (1979), and Hobbs and Erickson (1980)
reported no relationship between age and attitude toward science; and Breakwell and Beardsell (1992) reported increasing interest in science with increasing age.

Perhaps the most consistent finding in all of the earlier studies (and in the current study as well) was the association between gender and choice to major in science rather than to major in arts or humanities. For whatever reasons, females in many countries appear to prefer to concentrate their studies on arts and humanities disciplines rather than on science disciplines (e.g., Johnson, 1987; Kahle & Lakes, 1983; Osborne et al., 2003; Sjøberg, 2004; Sjøberg et al., 2004). Although many studies show the influence of gender on students’ attitudes toward science and on their choice of majors, research has not provided a definitive explanation for these patterns. Researchers, however, have pointed to a wide range of possible socio-cultural explanations for the influence of gender, including early childhood experience, family background, neighborhood influence, peer pressure, socialization in school, and cultural practices (e.g., Becker, 1989; Beoku-Betts, 2004; Halpern et al., 2007; Johnson, 1987; Jovanovic & King, 1998; Jovanovich, Solano-Flores, & Shavelson, 1994; Kahle & Lakes, 1983; Malone & Dekkers, 1989; Miller, Lietz, & Kotte, 2002; Rosenthal, Guest, & Peccei, 1996; Tiffany & Burnette, 2004; Weinburgh, 1995).

The studies of such gender disparities, moreover, have mostly been conducted in the United States, but the dynamics they reveal might be equally applicable to students in developing nations such as Sudan. In Sudan, for example, researchers have observed that the differences between how girls and boys are socialized are striking (e.g., O’Brien & Gruenbaum, 1991). Parents usually give boys more freedom to participate in outside activities than girls have. For example, girls might be required to remain at home
assisting their mothers with household activities (e.g., knitting, cooking, laundry, dishwashing, and so on), while boys often work or play outside the home (Tiffany & Burnette, 2004; Woolfolk, 1998). Such practices probably keep many girls from experiencing, learning, or getting acquainted with creative activities (e.g., farming, outdoor games, construction, and crafts) with possible relevance to the study of science (Tiffany & Burnette, 2004). These practices, which appear to reflect cultural norms, suggest that girls may be less likely than boys to graduate in fields related to science or to contribute to the scientific and technological development of their communities.

Nonetheless, the generally positive attitudes toward science reported by both the boys and girls who participated in this study offer hope that the schools in Sudan may soon begin to graduate more students, both boys and girls, with degrees in science.

Summary

This section of the chapter discussed the findings that addressed the research questions guiding this study. The discussion examined the findings in the context of related literature and drew on this literature to provide possible explanations for the most significant findings. The discussion also sought to interpret differences between the major findings of the present study and findings from previous studies. Notably, previous studies suggested associations between choice of major and each of the eight independent variables included in the study, whereas this study showed that gender, peer influence 1 (direction), and attitude were the only variables functioning clearly as predictors of the dichotomous dependent variable, espoused choice of a major in science (in contrast to arts or humanities).
The study also appeared to affirm findings from previous research showing that gender is consistently but negatively associated with choice of a science major (i.e., that females are less likely to choose science majors) and that peer influence (direction) is positively associated with students’ choice of a science major. It also appeared to confirm previous research that linked students’ attitudes toward science with their choice to take course in or major in science.

Implications for Practice

This section of the chapter suggests implications for practice that are based on the major findings of the study as well as on findings from related studies that produced similar findings. As noted previously, the study’s major findings concerned the potential impact of gender, peer influence, and attitude on students’ choice to major in science rather than in arts or humanities.

Despite some limitations relating to the reliability of the questionnaire used to collect data and the possibility that social desirability bias skewed responses, the findings of this study do provide at least tentative justification for significant changes in Sudanese secondary schools and possibly for school in other nations as well. Relevant implications for practice include suggestions about what schools might do to make science more appealing to girls, what schools might do to improve attitudes toward science in general, and what schools might do to make peers more supportive of one another with respect to the study of science.

Practical Implications Related to Gender

Overall, the decreasing number of girls in secondary school science disciplines has important ramifications for nations in both the developed and developing world.
These nations depend on the contributions of science researchers and professionals who fill a wide range of different jobs in the public and private sectors. School choices that limit girls’ opportunities to fill such jobs not only constrain these students’ career opportunities, they also keep nations from benefiting from the potential contributions to scientific fields of a large segment of their populations (Tiffany & Burnette, 2004).

Considering the significance of the problem of gender disparities in the level of interest in and the choice to study science, potential solutions might best be framed in the context of the possible causes of such disparities (Tiffany & Burnette, 2004). Some theorists and researchers have attributed these disparities to biological differences (Benbow & Stanley, 1980; Gray, 1981; Hyde, Fennema & Lamon, 1990; Linn & Hyde, 1989). If these theorists and researchers are correct, little by way of school-based intervention is likely to improve the situation. Many other researchers and theorists, however, have attributed gender-based disparities to features of the social and cultural environment (Ango, 2002; Mukundi, 2004; Osborne, Simon, & Collins, 2003; Tiffany & Burnette, 2004). Some evidence, moreover, suggests that the argument on behalf of environmental causes is stronger than the argument on behalf of biological causes (Hyne, Fennema, & Lamon, 1990; Linn & Hyde, 1989). These findings provide encouragement for science educators, most of whom would like to see greater gender equity in course-taking in science, the choice to major in science, and performance in science disciplines (Beoku-Betts, 2004; Tiffany & Burnette, 2004).

To improve gender equity with respect to participation in science, some researchers (e.g. Tiffany & Burnette, 2004) suggest that schools should establish norms for equitable participation among students, practice equitable classroom management,
accommodate various learning styles, connect science concepts to life experience, promote an environment of self-confidence and success, create a sense of community, provide students with positive female role models, and use gender-fair instructional materials. Even though the literature does not mention specific causes of the gender disparities in Sudanese schools, the recommendations above might represent a starting point toward achieving gender equity in that country. Additional research on circumstances in Sudan may be needed to serve as the basis for more definitive recommendations.

Practical Implications Related to Peer Influence

As mentioned previously, peer influence was the second most powerful predictor of students’ choice to major in science. In peer environments that do not support the study of science, students pay a social price for expressing interest in these disciplines. But in peer environments that value the study of science, students who express interest in these subjects reap rewards. Schools that hope to improve students’ attitudes toward and participation in science, therefore, would be well served by finding ways to cultivate peer environments that are supportive of students’ engagement with the study of science (Breakwell & Breardsell, 1992; Myers & Fouts, 1992; Simpson & Oliver, 1990). In supportive environments students might have opportunities to receive and provide peer tutoring, participate in debate clubs where science topics are addressed, and become involved with informal science activities in which parents and community members also participate.

Practical Implications Related to Attitude
In this study, students identified science topics that they considered to be important, relevant, interesting, and not too difficult to study. Their preferences suggested that they see some of what they study in science as valuable in its own right but see most of what they study as valuable because it is a means to an end (e.g., admission to college, a lucrative career, a healthier lifestyle). For instance, students appear to prefer to study science content that contributes to their personal livelihood and wellbeing or translates into immediate personal benefits (e.g., science the deals with health, career performance, and everyday life). Even though this perspective of students seems reasonable, it does not fit well with the traditional science curriculum in many high schools. As a result, educators might need to find ways to link science concepts to real-world applications, using students’ preferences as a way to sustain their interest in the study of science.

Some literature does address the challenge implicit in this recommendation. For example, some studies show that traditional teaching appears to discourage students from engaging in science classes as well as other school learning experiences (Ango, 2002). Nevertheless, this study as well as some earlier studies suggested that students’ attitudes toward academic learning, in general, and science, in particular might be improved through teaching that attends to students’ interests and makes what students find difficult easier to understand (Osborne, Simon, & Collins, 2003).

Many researchers (Brown, 1976; Cooper & McIntyre, 1996; Ebenezer & Zoller, 1993; Giordano & Rochford, 2005; Haladyna, Olsen, & Shaughnessy, 1982; Myers & Fouts, 1992; Osborne, Simon, & Collins, 2003; Simpson & Oliver, 1990) have studied what students and teachers believe to be effective practices for teaching science. These practices entail (1) clearly elucidating learning goals (Cooper & McIntyre, 1996;
Simpson & Oliver, 1990); (2) clearly communicating procedures and concepts (Cooper & McIntyre, 1996); (3) planning lesson with care (Cooper & McIntyre, 1996); (4) making explicit linkages between subject matter and students’ prior experiences and knowledge base (Cooper & McIntyre, 1996; Osborne, Simon & Collins, 2003); (5) allowing students to have input into goal and agenda setting (Cooper & McIntyre, 1996; Ebenezer & Zoller, 1993); (6) supporting students within the social context of classrooms in order to help them feel accepted, cared for, and valued (Myers & Fouts, 1992); (7) making allowance for different cognitive styles (Edward, 2005; Giordano & Rochford, 2005); and (7) accommodating students’ needs by modifying instructional strategies and learning activities in appropriate ways (Brown, 1976; Osborne, Simon, & Collins, 2003).

Implications for Future Research

This part of the chapter considers implications for future research relating to the major findings of the current study. These recommendations relate to (1) the research instrument, (2) full specification of a model for predicting choice of major, and (3) additional studies on the disparity between girls’ and boys’ interest in studying science.

The research instrument used in this study to measure attitudes toward science showed less than a modest level of reliability, suggesting that the instrument might not be well suited for use with students in Sudan (and perhaps in other African countries as well). Therefore, work to develop a valid and reliable measure of attitudes toward science is warranted as a way to expand understanding of such attitudes in Sudan and other African countries. Researchers might start the process of instrument development by conducting focus-group interviews with African students, scientists, and science educators. Using ideas surfaced in these interviews, researchers might then create a pilot
instrument and refine it through studies to measure its reliability, concurrent validity, and construct validity.

The present study examined students’ espoused choice to major in a science discipline (rather than an arts or humanities discipline) in relationship to predictor variables measuring attitudes toward science, gender, age, peer influence, parent influence, and family socio-economic status. The logistic regression model that incorporated these predictor variables, however, did not explain a large amount of the variance in the dependent variable (i.e., choice of major). Additional studies that include other variables, particularly those discussed in chapter 2, might be warranted in the African context in order to create a model that would better predict students’ choice of major. Future studies using qualitative methods also might help to identify the issues relating to science curriculum and instruction that African students believe are salient.

This study also pointed to gender disparities whereby girls in Sudan are less likely than boys to major in science. Researchers and educators, therefore, may need to understand the causes of this disparity in order to find ways to address it. Perhaps interviews with male and female students might provide insights into the cultural norms and practices in Sudan that reinforce such gender disparities. Furthermore, experimental or quasi-experimental studies might be developed in order to test the efficacy of different interventions for increasing girls’ confidence about learning science concepts or for improving girls’ attitudes toward science.

Chapter Summary

This chapter discussed the major findings of the study in the context of related literature. It started with a review of these findings, and then proceeded to examine how
these results fit with those reported in previous related literature. It focused attention on findings about the level of Sudanese students’ interest in majoring in science; the shared variance between attitude toward science, parents’ influence, and peer influence; and the association between gender and interest in science.

The chapter then turned to a consideration of recommendations for practice that addressed the study’s major findings. Relevant implications for practice included recommendation about what schools might do to make science more appealing to girls, what schools might do to improve attitudes toward science in general, and what schools might do to make peers more supportive of one another with respect to the study of science.

The chapter concluded with a set of recommendations for future research that would clarify or elaborate on the findings from this study. These recommendations relate to (1) the research instrument, (2) full specification of a model for predicting choice of major, and (3) additional studies on the disparity between girls’ and boys’ interest in studying science.
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Appendix A1

Pilot Study Instrument

START HERE:

A. My science classes.

To what extent do you agree with the following statements about the science that you
may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line
blank.)

1 School science is a difficult subject

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Lo disagree</th>
<th>Lo agree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

2 School science is interesting

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Lo disagree</th>
<th>Lo agree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

3 School science is rather easy for me to learn

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Lo disagree</th>
<th>Lo agree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

4 School science has opened my eyes to new and exiting jobs

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Lo disagree</th>
<th>Lo agree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
5. I like school science better than most other subjects
   Disagree       Lo disagree       Lo agree       Agree
   □              □                □             □

6. I think everybody should learn science at school
   Disagree       Lo disagree       Lo agree       Agree
   □              □                □             □

7. The things that I learn in science at school will be helpful in my everyday life
   Disagree       Lo disagree       Lo agree       Agree
   □              □                □             □

8. I think that the science I learn at school will improve my career chances
   Disagree       Lo disagree       Lo agree       Agree
   □              □                □             □

9. School science has made me more critical and sceptical
   Disagree       Lo disagree       Lo agree       Agree
   □              □                □             □

10. School science has increased my curiosity about things we cannot yet explain
    Disagree       Lo disagree       Lo agree       Agree
    □              □                □             □

11. School science has increased my appreciation of nature
    Disagree       Lo disagree       Lo agree       Agree
12 School science has shown me the importance of science for our way of living

Disagree  Lo disagree  Lo agree  Agree

13 School science has taught me how to take better care of my health

Disagree  Lo disagree  Lo agree  Agree

14 I would like to become a scientist

Disagree  Lo disagree  Lo agree  Agree

15 I would like to have as much science as possible at school

Disagree  Lo disagree  Lo agree  Agree

16 I would like to get a job in technology

Disagree  Lo disagree  Lo agree  Agree

B. How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines.

(Please tick only one box.)
None ........................... □

1-10 books...................... □

11-50 books................... □

51-100 books............... □

101-250 books............. □

251-500 books.......... □

More than 500 books... □

C. Background information

I am a □ girl □ boy

I am _____ years old

I am a student in ___________________ (write the name of your school)
Appendix A2

Main Survey Instrument

START HERE:

A. My science classes.

To what extent do you agree with the following statements about the science that you may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

1 I do not think I will use what I learn in math and science classes once I graduate from secondary school.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                  □           □        □

2 The things that I learn in science at school will be helpful in my everyday life.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                  □           □        □

3 In today’s world, studying math and science is more useful than studying other subjects like history and art.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                  □           □        □

4 School science has taught me how to take better care of my health.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                  □           □        □
5. I would like to have as much science as possible at school.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

6. School science has made me more willing to base judgement on evidence.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

7. I would like to become a scientist.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

8. School science is a difficult subject.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

9. School science has increased my appreciation of nature.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

10. My friends prefer science fields over arts or humanities fields.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □

11. I would like to get a job in technology.

   Strongly disagree   Disagree   Agree   Strongly agree
   □                    □          □        □
12 School science has shown me the importance of science for our way of living.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

13 I plan to major in a science discipline rather than an arts or humanities discipline.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

14 School science is interesting.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

15 I always chose what my friends recommend that I study.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

16 School science has increased my eagerness to learn about things we cannot yet explain.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

17 I like school science better than most other subjects.

Strongly disagree  Disagree  Agree  Strongly agree

□  □  □  □

18 My parents would like me to pursue a career in scientific or
19 I think everybody should learn science at school.

Strongly disagree  Disagree  Agree  Strongly agree
□  □  □  □

20 I think that the science I learn at school will improve my career chances.

Strongly disagree  Disagree  Agree  Strongly agree
□  □  □  □

21 School science is rather easy for me to learn.

Strongly disagree  Disagree  Agree  Strongly agree
□  □  □  □

22 School science has opened my eyes to new and exciting jobs.

Strongly disagree  Disagree  Agree  Strongly agree
□  □  □  □

23 I always listen to what my parents recommend that I study.

Strongly disagree  Disagree  Agree  Strongly agree
□  □  □  □

24 Studying math and science will not help me very much in the career I would like to pursue.

Strongly disagree  Disagree  Agree  Strongly agree
25 How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines.

(Please tick only one box.)

None □
1-10 books □
11-50 books □
51-100 books □
101-250 books □
251-500 books □
More than 500 books □

B. Background information

26 I am a □ girl □ boy

27 I am _____ years old

28 I am a student in __________________ (write the name of your school)
Appendix A3

Main Survey Instrument (Recoded)

START HERE:

A. My science classes.

To what extent do you agree with the following statements about the science that you may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Attitude 1  I do not think I will use what I learn in math and science classes once I graduate from secondary school.

S/disagree  Disagree  Agree  S/agree

□  □  □  □

Attitude 2  The things that I learn in science at school will be helpful in my everyday life.

S/Disagree  Disagree  Agree  S/agree

□  □  □  □

Attitude 3  In today’s world, studying math and science is more useful than studying other subjects like history and art.

S/ Disagree  Disagree  Agree  S/Agree

□  □  □  □
Attitude 4  School science has taught me how to take better care of my health.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Attitude 5  I would like to have as much science as possible at school.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Attitude 6  School science has made me more willing to base judgement on evidence.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Attitude 7  I would like to become a scientist.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Attitude 8  School science is a difficult subject.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Attitude 9  School science has increased my appreciation of nature.
S/Disagree  Disagree  Agree  S/Agree
☐  ☐  ☐  ☐  ☐

Peer influence 1  My friends prefer science fields over arts or humanities fields.
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Attitude 14  I like school science better than most other subjects.

Attitude 15  I think everybody should learn science at school.

Attitude 16  I think that the science I learn at school will improve my career chances.

Attitude 17  School science is rather easy for me to learn.

Attitude 18  School science has opened my eyes to new and exciting jobs.
Parent influence 2

I always listen to what my parents recommend that I study.

S/Disagree Disagree Agree S/Agree
□ □ □ □

Attitude 19 Studying math and science will not help me very much in the career I would like to pursue.

S/Disagree Disagree Agree S/Agree
□ □ □ □

Note: S = Strongly.

Books in home:

25. How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines.

(Please tick only one box.)

None □

1-10 books □

11-50 books □

51-100 books □

101-250 books□

251-500 books□

More than 500 books □

B. Background information

Gender:
26  I am a  □ girl  □ boy

Age:

27  I am _____ years old

28  I am a student in __________________ (write the name of your school)
Table 7

Frequencies

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Note:

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Note:
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Factor Analysis: Total variance explained

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Note:

Extraction Method: Principal Component Analysis
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