The Relevance of Science Education

As seen by Pupils in Ghanaian Junior Secondary Schools.

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A thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy in the Department of Mathematics and Science Education, University of the Western Cape.

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November 2006

DECLARATION

I declare that Relevance of Science Education: as seen by Pupils in Ghanaian Junior Secondary Schools is my work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Ishmael Kwesi Anderson November 2006

Signed………………………………………

DEDICATION

This thesis is dedicated to Nana Andah, Ekua Ewuduwa, Netseba Dede (children), Mrs. Sylvia Esi Anderson (wife), Madam Mary Aba Odoom (mother) and the memory of my late father, Rev. Philip Robert Anderson.

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RELEVANCE OF SCIENCE EDUCATION

AS SEEN BY PUPILS IN GHANAIAN JUNIOR SECONDARY SCHOOLS

Ishmael Kwesi Anderson

KEYWORDS

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Constructivism

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Comparative study

ABSTRACT

RELEVANCE OF SCIENCE EDUCATION: AS SEEN BY PUPILS IN GHANAIAN JUNIOR SECONDARY SCHOOLS

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This thesis is based on a larger international comparative study called the ROSE (Relevance of Science Education) project. The study investigates the affective factors pupils perceive might be of relevance for the learning of science and technology using the ROSE survey questionnaire; and is aimed at providing data that might form part of an empirical basis for local adaptation of the science curriculum.

The standardized ROSE survey questionnaire of 250 closed ended items that relate to some aspects of science and technology on a 4-point Likert-type scale was administered to Ghanaian junior secondary pupils at the end of compulsory schooling and mainly 14 to 16 year old cohort. The data for this study were collected from a sample of 1027 pupils drawn from all the 12 districts in the Central Region of Ghana in the year 2003. The survey covered six interrelated issues:

- information on the pupils' interest profiles in some topics in science and technology;
- pupils' general perspectives of the environmental challenges;
- information on the pupils' attitudes towards school science;
- significance of science and technology in society;
- pupils' views of some important qualities they attached to future job; and
- pupils' out-of-school experiences that might have bearing on science learning.

The information obtained was compared along:

- Male and female pupils;
- Rural and urban school pupils;
- Ghanaian pupils and pupils from other countries

The responses from the ROSE questionnaire were analysed through the use of SPSS (version 12.0.1 for Windows) and Excel. Descriptive statistics was conducted on the data and an independent sample 2-tailed *t*-test was used to explore the statistical significance of the differences in the items' mean at $p \leq 0.05$. An interview approach was used to gauge the pupils' perception of the ROSE questionnaire and used to validate pupils' responses.

In analyzing their responses, it became clear that, on the average, views expressed were common to all groups of pupils in Ghana (male and female, urban and rural). When analyzing details in the response pattern, it was noted that boys and girls, to a large extent, placed the same items on top as well as at the bottom of their priorities. The same pattern was also seen between urban and rural pupils. The study also observed areas where there was a mismatch between the interests of girls and boys, as well as between urban and rural pupils. Some of these differences were striking, and the details were equally explored.

The cross-national comparisons brought to the fore some similarities and differences between Ghana and the other ROSE partner countries about pupils' affective dispositions towards the learning of school science.

I argue, therefore, that any attempt to provide a universally valid science curriculum would not be appropriate if one wants to meet the priorities and interests of the learners. Data of the kind presented in this study should, in my opinion, be taken into account when science curricula are defined, textbooks are written and in the everyday teaching in classrooms.

November, 2006.

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Avotri *et al.* note:

> *In a fast advancing and changing technological world, science has become the backbone of development,… (Avotri et al, 2000: 36).*

Despite the growing importance of science and technology in all realms of life in any society, many young people appear to lose their interest for it in schools. This happens mainly in highly developed societies. It seems they have developed ambivalent attitudes to and perceptions of science and technology (Schreiner and Sjøberg, 2004). In the quest for solutions to the lack of interest that young people have for science and technology education, most research in science and technology education has focused on the cognitive sides of teaching and learning, but there is growing acceptance of the significance of the affective dimensions of the issue. This is of course also important in developing countries.

This thesis, therefore, aims to investigate Ghanaian Junior Secondary School (JSS) pupils' views and values regarding school science learning (science education). What do they make out of the science content they are expected to learn? Is it interesting or boring, easy or difficult, with more or little perceived relevance to their lives? Knowing more about their interests in and attitudes towards science education and also science may open way for alternatives and improvements.

This thesis is based on a much larger international survey project, the Relevance of Science Education (ROSE)[1]. Data reported here in this work, are based on the

[1] The ROSE project is based at the University of Oslo, Norway and is directed by Professor Svein Sjøberg. Details of the project can be found in Schreiner and Sjøberg (2004) and also available at http://www.ils.uio.no/forskning/rose. Some aspect of ROSE project is presented in section 3.3.3.

ROSE questionnaire, and are from pupils attending and at the end of compulsory schooling in Ghana, in particular Central Region in the early part of year 2003.

1.1.1 The area of survey research

Ghana is a small country located on the West Coast of Africa just north of the equator. It has a total land area of 238,305 km^2 and is bounded by French speaking countries. It is bounded on the north by Burkina Faso, on the west by Cote d'Ivoire, on the east by Togo and on the south by Gulf of Guinea. It obtained its independence from British rule in 1957 and became a republic in 1960. Before then it was called the Gold Coast. For administrative purposes, the country is divided into ten regions with 138 districts. It has a population of almost 20 million, 51% of whom is female and with about seventy percent (70%) of the population living in rural areas.

Ghana is a multilingual society. There are nine major ethnic groups, seven major languages, and more than one hundred dialects. Ghana has large variations in terms of location, differences in culture or ethnicity, and level of economic development. English is used as the official language of the country. English is not only the language of business and commerce but is also the medium of instruction at all levels of the education system beyond the Primary 1-3 stage, where the medium of instruction is the most dominant local language of the area in which the school is located. That is, English is taught as a subject in Primary 1-3, but after that it is both a subject and the medium of instruction.

1.1.2 Relevance: the key word in the ROSE project

The ROSE project is a study in science and technology education. The word *relevance*, which is chosen for the title of the ROSE study, is meant to embrace a wide spectrum of factors that belong to the affective domain. The study is aimed at providing a better understanding of a series of aspects that are related to young people's relationships with and emotions towards science and technology: their interests, perceptions, experiences, attitudes, plans and priorities. This implies that other key words could have been chosen, such as meaningful, motivating, interesting, engaging and important. However, *relevance* is deemed more appropriate, but should not be interpreted as a precise definition of the word.

What the young learners themselves express as their concerns in science and technology education are to be considered relevant to them. Therefore, anything of relevance to pupils is meant to be something which has interest and value for pupils to engage in rather than others (Gardner and Tamir, 1989). As a science educator, I believe that a way to successful science teaching goes through knowing something about the views and perceptions of learners. Such views and perceptions may position us better as science educators to think critically and constructively about alternatives and improvements.

1.2 Background

Education may be seen as a process by which individuals acquire knowledge, skills and attitudes, which enables them to develop their faculties in full. One of the benefits of good education is that it enables individuals to contribute to the development in the quality of life for themselves, their communities and the nation as a whole. When these dimensions of education are achieved, then science learning has become meaningful and fulfilling to the learner.

The development of science and technology is also recognized worldwide as vital for a nation's overall economic development. When used effectively science and technology is able to improve productivity and meet the needs of society. This has been demonstrated in the developed countries, and more recently in the newly industrialising countries, where science and technology have been responsible for more than half of the increase in productivity. Science education should therefore appeal to all learners, regardless of backgrounds. Pupils are likely to learn better when they are interested in the subject, hence it becomes important to know the interests of the pupils, and how this may vary with their background.

1.2.1 Rationale for the study

Ghana, like many of the African countries is still faced with challenges of underdevelopment. The environmental preservation, the combating and control of diseases, lack of culture of self-employment after leaving school, population control, food production, health and sanitation are some of the challenges that confront most of the developing countries in Africa. When one considers the key role science and technology continue to play in societies, especially in the developed countries, then Ghana, as a developing country, can not afford to follow recent trends in highly developed countries, where young people seem to lose their interest for science and technology in schools and further studies (see for example, Black and Atkin, 1996; Schreiner and Sjøberg, 2004).

However, some studies elsewhere have shown a general interest for Ghanaian pupils in school science. For example, the Science And Scientist (SAS) study revealed what pupils from different countries, including Ghana, were interested in learning about in science (Sjøberg, 2000a; 2002a). Sjøberg found low overall interests in Japan (confirming trends regarding science learning in a developed country). But pupils from developing countries, like Ghana, seem to be interested in learning about nearly everything. In general pupils from developing countries were found to be far more interested than pupils from more economically developed countries. The pattern in gender differences in interests seems to be similar, but to some varying degree. The gender differences in developing countries were less pronounced as compared to other industrial countries.

These are positive signs for Ghana that Ghanaian science educators could build on by introducing a sound science education programme that should attract the interests of all learners, regardless of social or geographical background or gender. When such interests are known and considered when science curricula are constructed or designed, then school science is likely going to be relevant to the needs of all.

The point of departure for this study is the affective dimensions of science learning. Affective factors play a very important role in learning outcomes. There is therefore the need to focus our attention on the attitudinal and motivational factors of science learning.

Many studies address the pupils' *alternative conceptions* in science. In these studies, researchers have found that school science learners hold ideas about science that are contrary to those of accepted science and hence in school science. A survey of such studies is regularly compiled and updated by Duit (2004). This database now contains some 4000 such studies, which indicates the proliferation of such research.

The demands for conceptual understandings and improved achievement appear to have influenced much educational research in science to focus on providing information about the *most effective ways* of achieving stated learning goals. This may create a platform for comparisons of the effectiveness of different teaching approaches at achieving stated learning goals. It is clear that testing of this kind might not allow for judgements to be made about how the interest or perceived relevance of school science is to the learners. Indeed, there are relatively few examples of research studies in science education which attempt to answer this question of learners' levels of interest in school science.

Nevertheless, reviews of such considerably fewer studies that address the attitudinal aspects (i.e. attitudes, interests beliefs and motivation) of pupils' relationship to science and technology have been published (e.g. Gardner, 1998; Osborne, Simon and Collins, 2003), and there is an increasing concern about such factors as equally important as the conceptual understanding and achievements on tests and assessments.

I am of the view that pupils' learning of scientific concepts can be improved when more attention is given to the affective dimensions like attitudes, beliefs, values, appreciation or interest. Sjøberg (2002a) and Fensham (2000a; 2000b) also argue that a science curriculum whose content includes the interests and the needs of the child may provide the child with school science that is likely to be relevant to the child of today. Children have different home backgrounds, different life experiences, interests, attitudes, values and priorities (Sjøberg, 2002a). Most contents of science and technology are likely not to be remembered by pupils, while the attitudinal outcomes are likely to last. Affective factors mean a lot for how pupils choose their future. Attitudes and interests are important determinants for the choice of school subjects and for the recruitment to science and technology studies and careers (Schreiner and Sjøberg, 2004).

There is limited evidence that using relevant context leads to a better understanding of the concepts involved compared to traditional teaching (Ramsden, 1997) but a curriculum that uses content that is related to familiar and interesting phenomena and experiences in the local environment of the pupils may lead to a more meaningful learning (Nganunu, 1998). There are a number of different methods of teaching or learning activities. All the methods serve various educational purposes and have different capacities of motivating pupils and of attracting their interests. However, teaching *interesting* content topics gives no guarantee that the teaching will be successful but it is certainly better than choosing issues deemed by the pupils to be boring at the outset (Schreiner and Sjøberg, 2004). This therefore calls for a change in two basic aspects of school science - the content and the pedagogy, if it is to respond to the needs of the learners as well as the needs of society. We must accommodate pupils' voice in curricula that continue to emphasise science as a body of established knowledge to be learnt (Jenkins and Nelson, 2005). Teachers should therefore plan their teaching in ways that motivate pupils, make direct use of knowledge about their interests and concerns.

Ghana has sought to increase and sustain interests in science and technology and science-related programmes at the secondary and tertiary levels of education. Though some progress has been made in this direction, the current rate at which pupils enter science and technology and science-related programmes may not lead to the attainment of the projections documented in Vision 2020[2].

Many underlying reasons have been advanced for the difficulty in sustaining such interests in science and technology studies. Some of the reasons, among others are outdated curricula which are irrelevant, difficult, and unfashionable and lack qualified teachers. These are very good reasons, but Ghana has, however, its own contextual factors that impinge on pupils' interests in science and technology studies. There have been little expansions in science-related occupations, which might otherwise motivate the youth to opt for science. The traditional science-related occupations, like medicine, nursing, pharmacy and engineering have been with us since independence, without any significant expansion towards modern science and technology-related occupations. Learners unable to enter into the traditional ones, unwillingly take to teaching, which is perceived to be unrewarding and less dignifying. This situation may therefore not attract the interests and better attitudes of learners regarding science and technology-related studies.

The decline in pupils' interests in school science and technology is due to pupils' disenchantment with school science, particularly for young women and pupils marginalized on the basis of their culture or location (Gardner, 1998; Seymour and Hewitt, 1997). It has reached crisis proportions in many other countries (Osborne and Collins, 2000 and Frederick, 1991). It appears there is not enough documented evidence to suggest this crises level in Ghana. But Ghana must be better positioned not to fall into a similar crisis that has befallen most of the developed countries regarding science and technology education.

[2] Vision 2020 is Ghana's long-term programme of objectives, which regards the adoption of science and technology as the tool by which socio-cultural and economic problems of the individual, the community and the nation will be solved. It is this aspiration of Vision 2020, which has called for the formulation of a science and technology policy for the country. The implementation of this policy is envisaged to move the country's economy to a middle-income status and an immensely improved standard of living by the year 2020. The science and technology policy outlines a clear vision, goals and policy measures. In addition, the policy calls for the establishment of mechanisms for the finance, management and evaluation of the performance of science and technology. Recognising that science is dynamic, the policy is to be reviewed periodically to meet the challenges of change.

Some educators have argued (see for example Opolot-Okurut, 2004) that any educational change needs to be backed by empirical data either to base decisions on or to inform the decisions that are arrived at. It is also argued that the continuing decline in the number of candidates choosing to study science at the point of choice requires a research focus on pupils' attitudes to science if the problem is to be understood and remedied (Osborne, Simon and Collins, 2003). Consequently, many research projects and initiatives have been launched nationally (Anamuah-Mensah, 1998), as well as internationally (see for example, Schreiner and Sjøberg, 2004) to improve on science and technology education regarding pupils' interests and attitudes. Given the importance of science and technology to any society, it is easy to understand why there are many initiatives to improve the situation.

1.3 Purpose of the Study

This study is meant to elicit Ghanaian Junior Secondary School (JSS) pupils' experiences, interests, priorities, expectations and images that are of relevance for learning of science. The information obtained is compared along:

- Male and female pupils;
- Rural and urban school pupils;
- Ghanaian pupils and pupils from other countries about relevance of science education.

The focus of this study is on pupils in Ghana, (in particular the Central Region of Ghana) but in order to understand these pupils better, they are studied against a background of pupils from other countries.

1.3.1 Significance of gender and rural/urban comparisons

Gender equity and equity with respect to social class or geographical background are on a high list of political, social and educational concerns in Ghana. Some of these concerns in education are how to make education more accessible to the female and the rural child and curriculum that is fair to both gender and class.

The decentralisation of governance and removal of disparity in social amenities are some of the political and social concerns. However, to reduce this type of inequalities has become a challenge that faces most of the developing countries. The two types of communities (urban and rural) in Ghana are in the extremes with respect to most statistical indicators, like educational level, income, and occupational pattern. Growing up in these two different types of community represents great disparities in a Ghanaian context. According to Sjøberg (2000b), it is reasonable to expect that children in these areas would get different life experiences, hopes and aspirations, and that one might expect them to demonstrate very different interest profiles at school science. There must therefore be a conscious effort to make a curriculum that is fair to the various groups of pupils. I argue for a *local* curriculum that considers the voice of all groups of pupils (thus a curriculum that favours girls and boys, as well as rural and urban pupils). It has also been proposed elsewhere (AAUW, 1998) that the identification and removal of any barriers that discourage or impede equitable access and opportunity for all students is a goal that should be continuously monitored and investigated.

As pointed out above, I therefore compared the data from these two perspectives for Ghana in order to shed light on the relative importance of the geographical and gender aspects for the discussion of the science curriculum.

1.3.2 Significance of international comparative studies

International comparative studies in education may function in many ways. Such studies may be undertaken in order to develop a better knowledge of the functioning of the education system in a given country and to provide information for facilitating national education policy dialogue and policy formulation in order to improve the system under study.

National human resources and institutional capacity building are also key elements of such studies. Though, we may get diverse messages, through such collaborative studies, national expertise and institutional capacities are being consolidated. As such, governments can increasingly rely on their national capacities to undertake related studies in education sector.

A participating country in an international comparative study is likely to open up for diversity in visions, alternatives, promoting critical discussion, offering new ideas for experimentation, and above all, learning from others.

Cross-cultural comparative studies thus enable a country to compare the similarities, as well as the differences, between the related activities carried out in the various national contexts. This may offer a better understanding of the lessons learnt or drawn from policy formulations and education sector improvement strategies adopted by other cultures.

Large-scale comparative studies like TIMSS[3] (Third [later T for Trends] International Mathematics and Science Study), which mainly addresses the achievement issue relative to the curricula in each participating country, may provide governments and ministries a platform to deal with performance and achievement issues. The 'TIMSS-like' testing is sometimes used by donors (like World Bank and United Nations Educational, Scientific, and Cultural Organization-UNESCO) as condition for funding of education in developing countries.

However, such studies are likely to have a normative effect on education, such as having the tendency to put pressure to standardized curricula and learning outcomes. Science education for example, might therefore appear to be universalised and harmonized to become alike as a result of such standardization.

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[3] TIMSS 2003 is the fourth in a series of studies undertaken once every four years by the International Association for the Evaluation of Educational Achievement (IEA). TIMSS 2003 seeks to continue to monitor trends in science and mathematics at the eighth grade and at the fourth grade. Ghana participated only at the eighth grade. Ghana's participation has enabled the country to find out the performance of the eighth graders in science and mathematics as compared with other countries. I will return to it in more detail in chapter three.

Studies of this nature are likely to establish benchmarks for contents, aims and assessment methods in education; and ‘winners of the race’ may become models and ideals for other countries. The need to identify ‘common’ items is likely to remove contexts from the items and secrecy about items may make ordinary academic critique impossible, yet some governments may even legitimize their educational reforms and initiatives by reference to TIMSS results. This is probably because of the rankings of countries in terms of performance (which most often are based on a measure on only a few aspects of a few subjects). The rankings are likely to be accepted by the public and politicians as a valid measure of the overall quality of the school with its effect of trivializing the purpose of schooling. The educational policies in developing countries, in particular, are likely to become ‘TIMSS-driven’ in the years to come.

The ‘real life challenges’ of children and their cultures differ; and the social and cultural values, beliefs, and practices of society, community, and family influence children’s personal and affective dispositions (Huang and Yore, 2003). Therefore, any attempt to provide generalized description of science contents must be viewed with caution because of the diversity within a society and the dynamic changes in a society.

The ROSE study, on the other hand, wants to open up for variation and differences, based on a belief that ‘science and technology education for all’ should primarily prepare the young people to meet the challenges in their own life and environment (Schreiner and Sjøberg, 2004).

The international comparisons in this thesis are therefore intended to see Ghana’s own national priorities and choices in science education with new eyes. This may lead to better understanding of national peculiarities, and may further open up for an awareness of alternative. In summary, Ghana may be better prepared to construct curricula and learning experiences that meet the needs of the learners.

Developing countries and international comparative studies

The involvement of developing countries in international comparative research projects is laudable, as it aims, among others, at networking and capacity building of researchers especially in the developing countries. As mentioned earlier, some international donors base the funding of education sector in developing countries, for example, on outcomes of such studies. However, the challenges that are faced by such societies during the execution of these projects are enormous. The practicalities and realities of the projects are sometimes compromised. Attempts to generalise findings to national populations become uncertain and likely open to criticisms. Hence the interpretations of results are at times done with caution and care.

Some of the major challenges that continue to confront some of the developing world, to mention a few, are logistics, resources for travel (including accessibility), human capital, existence of reliable educational statistics and other forms of communication, such as efficient postal system, telecommunication network and transport system especially to the remote areas when rural communities are involved in such projects.

These constraints may impact negatively on sampling, hence to be strict on sampling techniques and participation become unrealistic. When the intended target population is a whole age cohort of a section of school pupils, most often the proportion of that age cohort at school in many developing countries is much lower than that of the industrialised or developed countries for some obvious reasons. Hence, some proportion of school pupils in many developing countries may not be representative of the national age.

For these reasons, when the main focus of an international comparative project is on pupil assessment, such as TIMSS project, which may require ranking of countries in terms of performance, the findings may stand the risk of being misinterpreted. Hence, there is a need for an informed and critical debate about use and potential misuse of the findings. However, they may provide rich information that might be used for critical reflection. But other projects that focus on the affective dimensions of learning, for example, ROSE study, the data from such project may shed light on the importance of these factors for learning with regard to differences and similarities based on culture, gender and as well as geographical background.

Culture may play a significant role in the way different peoples respond to attitudinal surveys. In cultures where loyalty and respect for authority are valued, like most of the countries in sub-Saharan Africa, respondents are likely to consider more carefully the impact that their answers might have on the researcher. They may resort to responding more positively to questions than their counterparts in the developed countries. Such considerations imply that care should also be taken when comparing scores on attitudinal questions across cultures. Nevertheless, international comparative studies do provide some educational information.

1.3.3 Research Questions

I will address the research questions posed for this study that emerge directly from the international ROSE questionnaire. The questions are:

- What do children in Ghana want to learn about in science?
- What views do these children hold about environmental challenges?
- How do these children relate to school science?
- How do these children look at various aspects of the role of science and technology in society?
- What are the priorities of these children towards potential future occupation or job?
- What kinds of science-oriented experiences do these children have from their lives outside schools?

These questions are further addressed from gender and rural-urban pupils' perspectives, as well as to look at some aspects of Ghanaian pupils' relationships with science and science education through the lenses of the international patterns. And finally, I will enumerate the possible implications from these data with regard to the science curriculum.

1.4 Some facts about the countries that are compared

Some 40 countries participated in the international cross-cultural comparative ROSE project. The information about the views pupils at the end of the compulsory schooling hold for science and technology has been obtained for the countries. The datasets from the countries are part of the larger international data obtained through the ROSE project instrument. The datasets used for the purpose of comparison in this study were obtained from ROSE organizers in Norway.

1.4.1 Some Human Development Index values.

A Human Development Report (HDR) [4] for all countries is published annually by the United Nations Development Programme (UNDP). The countries, in each of the report, are ranked according to a Human Development Index (HDI)[5] (UNDP, 2003). The index is a measure of an average national achievement in three dimensions of human development: income, education and health.

According to Sicinski (1976), cited in Schreiner (2006), the level of technological development of a country influences people's expectation to the expected benefits of developments in science and technology. Sicinski remarked further, in the same study, that people in developed countries are less confident about future achievements of science than people in less developed countries.

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[4] According to the 1993-2005 UNDP Human Development Report: Human Development is a process of enlarging peoples' choices. In principle these choices can be infinite and change over time. But at all levels of development, one of the essentials for people is to have access to resources needed for a decent standard of living. If this choice is not available, many other opportunities remain inaccessible.

[5] HDI is a summary measure of human development based on the weighted average of three indices: (1) a long and healthy life, as measured by life expectancy at birth, (2) education, as measured by the adult literacy rate (two-thirds weight) and the combined primary, secondary and tertiary education gross enrolment ratio (one-thirds weight), and (3) a decent standard of living, as measured by GDP per capita in US$.

Schreiner also maintains that the level of technological development in a country is a key factor for explaining the expectations people have of further developments (Schreiner, 2006). In the SAS study, for example, Sjøberg found that pupils in developing countries have far more positive images of scientists and their potential for helping people than pupils in developed countries (Sjøberg, 2000a).

The international perspectives in affective studies can be based on HDI as an indicator for the level of development, the cultural life in a country and as well as geographical closeness. The culture of a country may play a key role in explaining people's views as they relate to science and technology. For example, Sjøberg and Schreiner (2005b) revealed that the views and values of young people and their ways of understanding themselves, their surroundings and the world are products of the culture in which they are growing up.

In this study, the countries that have been used for comparison with Ghana represent three main clusters of countries, these are: High HDI countries including all the European countries, Japan and Trinidad and Tobago; Medium HDI for Oriental (and Baltic) countries; and Low HDI for African (in particular, sub-Saharan African) countries respectively (see table 1-1). This classification of countries into high, medium and low HDI values is adopted from Sjøberg and Schreiner (2005b).

1.4.2 Some social and cultural values of the countries

Issues that are perceived to be meaningful to young people in a country may depend on the culture and the material conditions in the country. Therefore the youth's values, views, aspirations and ways of understanding themselves, their surroundings and the world are linked to the culture in which they are growing up (Schreiner and Sjøberg, 2006).

Societies in sub-Saharan Africa (for example, Ghana) are extended family-centred. Individuals grow up being taught the importance of acting obediently and conforming to common expectations in order to maintain harmonious relationships with others. Family closeness and loyalty are highly valued and are tied to parental authority. Listening is more important for children than expressing their own opinions. Parental control and protection are still dominant until they are adults, because African children are viewed as an extension of their parents. They protect children in every aspect of their life in order to ensure that expectations are met. It is not uncommon to find African children depending and relying on their parents. Most African parents, when having the opportunity, pay more attention to educating children in an academic orientation than in social orientation. The identity formation as the child grows may be constructed based on sex/gender and background influence, such as parental, societal, and cultural influences.

Table 1-1. Some selected Human Development Index values for countries participating in ROSE.

Countries	HDI - value	Life expectancy at birth (years)	Combined gross enrolment ratio for primary, secondary and tertiary schools.	GDP per capita (ppp US$)	Life expectancy index	Education index	GDP index	GDP per capita (ppp US$) rank minus HDI rank
Lesotho	0.497	36.3	66	2,561	0.19	0.76	0.54	-26
Swaziland	0.498	32.5	60	4,726	0.12	0.73	0.64	-47
Zimbabwe	0.505	36.9	55	2,443	0.20	0.78	0.53	-20
Uganda	0.506	47.3	74	1,457	0.37	0.71	0.45	6
Ghana	0.520	56.8	46	2,238	0.53	0.51	0.52	-11
Bangladesh	0.520	62.6	53	1,770	0.63	0.45	0.48	-1
Botswana	0.565	36.3	70	8,714	0.19	0.76	0.75	-70
India	0.602	63.3	60	2,892	0.64	0.61	0.56	-9
Turkey	0.750	88.7	68	6,772	0.73	0.84	0.7	-18
Philippines	0.758	70.4	82	4,321	0.76	0.89	0.63	19
Russia	0.795	65.3	90	9,230	0.67	0.96	0.76	-3
Malaysia	0.796	73.3	71	9,512	0.8	0.83	0.76	-3
Trinidad & Tobago	0.801	69.9	66	10,766	0.75	0.88	0.78	-6
Latvia	0.836	71.6	90	10,270	0.78	0.96	0.77	7
Estonia	0.853	71.3	92	13,539	0.77	0.97	0.82	4
Poland	0.858	74.3	90	11,379	0.82	0.96	0.79	12
Czech Republic	0.874	75.6	80	16,357	0.84	0.93	0.85	7
Portugal	0.904	77.2	94	18,126	0.87	0.97	0.87	5
Greece	0.912	78.3	92	19,954	0.89	0.97	0.88	2
Spain	0.928	79.5	94	22,391	0.91	0.97	0.90	3
England	0.939	78.4	123	27,147	0.89	0.99	0.94	3
Denmark	0.941	77.2	102	31,465	0.87	0.99	0.96	-9
Finland	0.941	78.5	108	27,619	0.89	0.99	0.94	3
Japan	0.943	82.0	84	27,967	0.95	0.94	0.94	2
Ireland	0.946	77.7	93	37,738	0.88	0.97	0.99	-6
Sweden	0.949	80.2	114	26,750	0.92	0.99	0.93	14
Iceland	0.956	80.7	96	31,243	0.93	0.98	0.96	4
Norway	0.963	79.4	101	37,670	0.91	0.99	0.99	2

Source: UNDP-Human Development Report 2003. Also available at http://www.undp.org/hdr2002/indicator/cty_f_NOR.html

For Western and industrialized countries (for example, Norway), nucleus family-centeredness is a norm for all societies. Children develop their free will to be independent and responsible individuals. Children are inherently independent individuals. Parents tend to encourage their children to be independent and confident at an early age. Parents believe children were born with their own ability and the children's future is earned by their own efforts. Therefore, one's identity is likely to be addressed through one's own personal choices (see Tseng, 1972; Côté, 1996 cited in Schreiner and Sjøberg, 2006; Hwang, 1998). Hence youth in modern societies, like Norway, regardless of home background may feel culturally, socially and geographically independent to choose their own identity. Unlike youth from less developed countries, they tend to be free to choose lifestyle and address their own values and aspirations.

The Oriental (Asian) countries (Malaysia, as example) have societal beliefs and expectations towards life almost similar to that of a sub-Saharan African country (see for instance, Quoss and Zhao, 1995). Family closeness and loyalty to parental authority are very much respected. The nation stresses on hard work, sacrifice and education is on high priority. However, the rapid growth in the Asian countries may challenge these traditions.

1.5 Significance of the study

The empirical findings or results from this study can help to position stakeholders and policy makers in education in Ghana to make informed judgements about what pupils would want to be taught in their school science courses. Through that, they can identify the contextual variables that may be modified to bring about improvement in curricula and writing of science textbooks in order to enhance interest in learning and teaching of science and technology for different groups of learners in particular. In other words, the results can be used to shed light on at least some aspects of the issue concerning gender equity and equity based on geographical background in science education.

The study will provide insights into the degree of accessibility pupils have to modern technology (ICT) equipments, status or level of use and identify what skills the pupils have in order to benefit from using the computers in science education. The issue of pupils' ICT skills are to be considered as very important determinant for the introduction and success of information technology in schools and effective use of instructional time.

Identifying pupils' future career orientation and the possible relationship with interests towards science learning will help to present education system with a view to ensuring their relevance to the development of human resources for the nation in the light of new challenges facing the nation.

Environmental problems in developing countries especially Ghana has continued to exist as a major challenge. Accra, the capital of Ghana and other metropolis/district capitals are more faced with this challenge. These areas are the economic nerve centres of this country and are stressed with environmental degradation due to overpopulation, lack of proper environmental practices and the poor environmental education knowledge of its younger generation. Lack of proper method of educating the school children is yet to be tackled in order to bring about significant change in attitude that will produce favourable action towards the environment. The development and validation of a reliable instrument therefore becomes essential for assessing pupils' attitude to the environmental challenges. This study is significant in that it contributes to the knowledge base about pupils' understandings of the environment. According to Payne (1998), it is essential for research in environmental education to identify pupils' conceptions and understandings about the environment. Through this, it is hoped the Ghanaian society might achieve the development of an informed population that respect the values of a sustainable development.

In this study pupils provide information about the experiences gained through out-of school activities. That information which may have bearing on their interests in science and technology will give teachers, curriculum designers and textbook writers an insight into the kind of science and technology-related experiences young learners bring to school, and how these may vary between girls and boys, and between rural and urban pupils for the use in their various endeavours.

This, it is believed, will help offer all stakeholders in science education realistic settings for combining pupils' voices and expected content knowledge in their designs towards the attainment of science education which will be more relevant to young learners.

Furthermore, the impact of the research provided by related education sector studies on policy formulation in the country will need to be further explored, and it is my hope that the findings of this study will contribute to this task.

1.6 Organization/structure of the study

The study is organized in fourteen chapters. The present chapter discusses the background for the study. The purpose of the study, the formulation of research questions, some facts about the countries that are compared with Ghana and the significance of the study are presented. Chapter 2 outlines briefly the system of education in Ghana and the background information on Ghana's educational reforms. This chapter also provides the context of the study and the status of science education in Ghana. Chapter 3 provides detailed information on both the national (local) and relevant international initiatives in science education in Ghana.

Chapter 4 focuses on the review of literature that relate to the present study on science education. The methodology of the study regarding its implementation is presented in Chapter 5. The chapter describes in detail the research methods and their relation to the analysis and interpretation of data from the study. It also discusses the survey instrument used for the study. Chapter 6 reports on the sample distribution characteristics and socio-economic status of parents of pupils in the sample. Chapter 7 to Chapter 12 will be devoted to answering the research questions that are posed in this study. Each of these Chapters is broken into two main sections. One section presents results and the other focuses on the discussions of the findings based on the information gathered from the respondents.

In Chapter 13 the findings and the discussions of pupils' interviews on their views about the ROSE questionnaire are presented. Finally, the implications for reviewing the junior secondary science curriculum in Ghana; the summary of the findings, conclusions and recommendations are provided in chapter 14.

2. THE RESEARCH SETTING

2.1 Introduction

This chapter provides contextual considerations and is broken into three main parts. First, I will look at a brief history of educational development in Ghana, including the context for the study. Then I will continue with the status of science education in Ghana.

2.2 A brief history of educational development in Ghana

This section presents an overview of the traditional and present structure of the education system in Ghana resulting from restructuring efforts undertaken within the 1987 education reforms. Parts of the information presented in these sections are direct quotes from the work of Anamuah-Mensah (1994; 1995; 1998).

2.2.1 The traditional structure of educational system

The traditional education system from the time of independence in 1957 to mid-1980 comprised six years of primary education, four years of what was then called middle schooling, and a seven-year secondary education (five years of preparation towards the Ordinary Level Certificate and two years of Advanced Level training) before entering degree granting institutions. Though, only a small proportion of pupils reached the university level of education, the average age of the first-year university students in Ghana was often about twenty-five.

Pupils at the middle schooling took either the Middle School Leaving Certificate Examination and terminated their studies, or, at anytime from seventh to tenth grade, the Common Entrance Examination, which admitted them to secondary or technical study. Most pupils, however, did not continue formal instruction after the first ten years of education. Ghana’s education (both structure and content) for that period was based on British system of education.

However, by 1983, the quality of education had dropped drastically as a result of poor management and supervision, inadequate funding for infrastructure, maintenance and teaching/learning resources. The enrolment rates went down, the number of trained teachers declined significantly, unemployment among school leavers increased and there was a marked decline in examination performances. Therefore various commissions and committees were set up to chart new directions for the country's educational system.

2.2.2 The new structure of educational system

As a result of earlier proposals for reform and partly in keeping with government's economic reform programme, fundamental change in the educational structure of the country was undertaken in the mid-1980s. Though the reform was based on the principle that literacy is a basic right of every Ghanaian, the overall goals were to make curricula at all levels more relevant to the economic needs of the country, to reduce the length of pre-university instruction, and to improve the quality of teacher preparation. Increased enrolment in primary schools and a reduction in the rate of illiteracy were also to be pursued. Successive governments in Ghana have aimed at making education more relevant to the world of work after school, to rural development and modernization of the predominantly agriculture-based economy, as well as the need to promote national and cultural identity and citizenship. However, results have been mixed.

In 1987, a new structure and content of education in Ghana became operational with initial focus on the implementation of the junior secondary school (JSS) programme. The policy decision on the new structure was based on an earlier Government White Paper entitled: The New Structure and Content of Education (MOE, 1974). However, despite a number of committee reports and proposals for educational reform, until mid-1980 the education system continued to place emphasis on traditional academic studies.

Under the new structure, the 6-3-3-4 system of education was adopted. The country now has 6 years of primary school education, 3 years of junior secondary school education, 3 years of senior secondary school education and a minimum of 4 years of tertiary education. The six years of primary school and three years of junior secondary-school education constitute the basic education level, which is supposed to be compulsory and free for every Ghanaian child of school-going age.

There is also opportunity for polytechnic (technical and vocational) education and teacher training education after senior secondary education. Apart from increasing participation, emphasis was placed on vocational education starting at the basic level in order to produce school leavers capable of fitting into the world of work or creating jobs for themselves. These wide-ranging reforms in mid - 1980 have brought the structure of the education system closer to an American model, aiming to make education more responsive to the nation's manpower needs rather than purely academic.

2.2.3 Ghana Educational Reform: What went wrong?

Ghana has seen various forms of educational reforms since the attainment of independence in 1957. Until mid-1980, the main focus was on development of new curricula at all levels of education. The range of science content was expected to extend beyond the traditional conceptual content of physics, chemistry and biology to include applications of science and technology.

Despite this, one of the most significant aspects of new science curriculum in Ghana was only a pragmatic reduction in the range of content in the 1980s and 1990s. This has resulted in the retention of much of the traditional content with little new material on 'technology and development' at the basic level of education. Hence, pupils continue to find the science they are learning at school isolated from their everyday experiences. It is therefore not surprising that, more recently, there has been general agreement from the public that the latest education reforms in 1987 has failed to meet expectations in terms of its coverage, quality, equitableness and economic utility (MEYS, 2004).

Science can no longer be detached from the values and priorities of the societies in which it is embedded. For this reason, the evaluation of science education curricula should be an on-going process that provides input and feedback to guide, change and offer directions for the programme and its modification (Njoku and Anyakoha, 1992).

The education reform programme succeeded in solving some of the problems confronting the education sector, including the reduction of the duration of pre-tertiary education from 17 to 12 years and expanding access to education. However, the sector was still beset with a number of problems. These included the following:

- Poor quality teaching and learning;
- Weak management capacity at all levels of the educational system;
- Inadequate access to education;
- Inadequate provision of infrastructure facilities in schools (direct quotes from Anamuah-Mensah, 1994).

The general consensus among Ghanaians now, especially government, educational professionals, parents and employers is that the innovation of a three-year JSS system to cap a six-year primary education course has failed to deliver its promise of equipping the youth of age bracket of 12-15 years with directly employable skills for world of work (MEYS, 2004). Skills in information and communication technology (ICT) literacy are needed by the work force of a modernizing economy, yet the JSS system has failed to do more to strengthen the basic skills in ICT. However, in the same vain, this age bracket youth is still immature to absorb the skills of craftsmanship and industry. The skills of craftsmanship and industry are some of the unrealistic goals that were set for technical and vocational education in Ghana.

It appears too many subjects are taught at the basic education system. Also, these subjects are likely to be taught poorly due to shortage of qualified teachers and materials especially in the rural communities. This may result in pupils of average ability unable to acquire sufficient grounding in basic literacy and numeracy and might not attain an international competitive standard as promised by 1987 education reforms. The results for Ghana from the TIMSS for the year 2003, which was released in the year 2004, confirm this assertion (see for example, Anamuah- Mensah *et al.*, 2004). I shall discuss in more detail some results for Ghana from TIMSS in section 3.3.2. Another challenge which seems to confront the current education reforms is that the basic education system appears to fall between the two schools of good intellectual formation on the one hand and practical skills training on the other.

2.3 Context for the study

In Ghana, school science is compulsory at basic education level (the primary and the junior secondary education levels). The compulsory science has different names at various levels of education. It is called integrated science at primary level, general science at junior secondary level and back to integrated science at the senior secondary level. The integrated science at the senior secondary level is a core subject for all pupils at that level.

Though the science carries different names at different levels, its components are similar. The components are mainly the traditional science subjects. Junior secondary school pupils are expected to pass the general science at the BECE[6] to gain admission to the middle-level education.

[6] In Ghana, junior secondary school pupils sit for Basic Education Certificate Examination (BECE) at the end of the third year (JSS3). This is a common national examination conducted by

This study is, however, confined to the third year pupils in both rural and urban junior secondary schools in Central Region of Ghana.

2.4 The Research focus

I look at science and technology as a key player in the development in every nation; this is because nations that have control of science and technology have been able to cope with global issues such as conditions of poverty, poor sanitation, illiteracy, disease, rapid increase in population and malnutrition. In this study, it must be understood that the use of science education embraces technology education as well. The role of science and technology in the contemporary world, calls for a special attention, and a focus on science and technology education at all levels of education. A good foundation is therefore necessary in the early years of any Ghanaian child. The realisation that science is applied in everyday life makes it imperative that children are encouraged to study science and understand it better.

2.4.1 Science and technology education in Ghana

Any country striving to develop in order to raise the standard of living of its population and maintain a balanced economy must as a matter of necessity adopt science and technology as the basis for achieving sustainable development. This, I believe, is the role that science and technology has played in transforming traditional European economies to the present high income levels. Ghana, as nation recognizes the importance of science and technology in national development. Hence, since the attainment of independence, successive governments have endeavoured to make science and technology a basis for the country's development.

West African Examinations Council. Among other subjects, they are expected to pass the general science at the BECE to gain admission to the middle-level education.

Ghana had its independence from Britain in 1957 and became republic in 1960. It was the first black African country in sub-Sahara to get independence. But Ghana, like most of post independent countries, especially in Africa, was faced with the problems of malnutrition, poverty, disease, illiteracy, low life expectancy and low industrialization. Science and technology education was accepted by the nation as the engine that could drive the move to overcome these problems associated with underdevelopment.

The government, in early 1960s, established economic and educational policies, which resulted in an increased access to education (Anamuah-Mensah, 1994). The emphasis was on science teaching and the establishment of industries in both urban and rural communities. The University of Science and Technology in Kumasi, was also borne out of the policy to train engineers, architects and scientists to operate these industries. This together with the University of Ghana in Accra, the University of Cape Coast in Cape Coast and in addition, polytechnics, Diploma certificate awarding institutions, teacher training colleges and technical schools instituted admission policy that favoured the admission of more pupils into sciences and science education. However, the quota allocation was hardly filled. The government had to institute some incentive package to move human resource development in the direction of science and technology. There was an easy access to scholarships for science courses. Science and mathematics students in the universities as well as science and mathematics teachers in secondary schools were offered inducement allowances. This period also witnessed massive inflows of voluntary service corps and a number of financial aids from the international developed communities both in the former Eastern and Western blocks. These services went mostly into improving on science teaching and learning.

As the local industries saw expansions in their activities and increase in profits, many of the industries established scholarship schemes to provide assistance to the needy but brilliant pupils at both secondary and tertiary levels of education. Some of the industries also offered opportunities to students, especially students of the University of Science and Technology and the polytechnics whose areas of studies have direct bearing on the activities of those industries, to have technical training during the long vacations. This was meant to raise their competences in the use of scientific and technological skills prior to their engagements with the industrial activities. The foreign exchange earnings from the cocoa industry, which was one of the major backbone on which the nation rely on to boost the economy, provided some science students and other students at the secondary schools with bursaries. Most of the students were either the wards of cocoa farmers or located in rural communities in the cocoa farming areas. This was to reduce the burden of financial commitments of the rural farmer.

During this period a closer relationship was sought between the culture practices of the people, their environment and workplace and the science subject taught in the schools (Anamuah-Mensah, 1998). Science as a unit (physics, chemistry, biology and agriculture were combined) was made compulsory at all levels of pre-tertiary education. Some training colleges were designated as science colleges to train science teachers for the basic level of education in order to increase access to science learning at that level. Many other initiatives have been instituted to boost the teaching and learning of science.

After many years of independence and despite the various actions, such as policies and initiatives by successive governments, not very much has been achieved in our effort at developing the nation through science and technology education. Ghana still faces the problems of underdevelopment. The status of science education and application of modern technology for industrial and agricultural purposes have increased, but not to the expected levels when compared to some Asian countries, like Malaysia, who had independence around the same time as that of Ghana; though, they may be other contextual factors that might have contributed in propelling Malaysia into an emerging industrial country. Incidence of diseases, unsanitary conditions, and environmental degradation are common occurrences. It is clear to deduce that the introduction of science and technology education as a vehicle to facilitate Ghana’s development has not been very much successful. Many Ghanaian science education researchers have elaborated on the causes for the present state of science education (See for example, Anamuah-Mensah, 1994; 1998, Anamuah-Mensah *et al.*, 2004; Fredua-Kwateng and Ahia, 2005). Prominent among the causes are the neglect of the indigenous culture in the development of science curriculum and in instruction. Anamuah-Mensah writes:

> *Science (like the traditional culture) has its own values, norms, practices, and beliefs and is therefore a culture in its own right. However, the scientific culture has been presented to the African child as part of the Euro-American culture and the African is therefore required to imbibe the western culture when learning the scientific culture (1998:5).*

Aikenhead (1997), for example, also argues for a cross-cultural science curriculum that permits pupils to move between various cultures and subcultures (e.g. the culture of the nation, the subcultures of science and school science). And those teachers who hold beliefs enabling them to take a cross-cultural perspective towards the curricular and instructional environment will ultimately be able to assist pupils as they encounter different cultures and subcultures.

Another area of concern is the teaching methodology. The teaching methodology in Ghana appears to consist more of straight lectures or direct-teaching, which requires the pupils to listen attentively throughout the duration of the instruction. It is likely that the pupils' interest might not be stimulated enough to enjoy science as a form of knowledge construction but function more as a validation of a *given* knowledge (Fredua-Kwateng and Ahia, 2005). The result is that science learning is reduced to rote learning and memorization. This form of science education in Ghana only reproduces and reinforces our economic and technological underdevelopment. Looking at the range of problems that confront Ghana, the most appropriate science pedagogy must be knowledge construction for problem-solving and problem-posing. Another area which has affected the country's science and technology efforts, relates to coordination of these activities. Essentially, there was no coordination mechanism to make it possible for activities to be integrated to reduce duplication of efforts and to promote synergy.

The junior secondary school and science and technology education in Ghana

At the junior secondary school, the science which is taught is referred to as general science and is compulsory for all pupils at this level. The subject areas of general science are physics, chemistry, and agriculture (including earth/soil science) biology (including botany, zoology, and health science) with very little on technology; this is because technology is taken as a vocational technical subject at the JSS. In most JSS the general science is not taught as an integrated subject, but rather as 'stand-alone' subject areas. Some of the reasons given for individual subject teaching are:

- lack of expertise in integrated science teaching, and
- lack of resources such as textbooks and laboratory materials and equipments.

All pupils at this level of education are required to pass general science in their national examination called Basic Education Certificate Examination (BECE) before they are able to secure admission to senior secondary school. In an attempt to complete the expected content, teaching methods are not varied. The teaching methodology as mentioned earlier, consists of the traditional 'chalk and talk' teaching with limited extent of hands-on learning activities or project work.

There is great variety of teaching methods which have different capacities of motivating and attracting pupils' interests. But instructional methods that are based on inquiry and construction of knowledge are to be encouraged such that pupils can probe or investigate both their physical and biological environments and find meanings to the natural occurrences. This may lead to both knowledge construction and validation.

However, according to Fredua-Kwateng and Ahia (2005), occasionally such investigation or activities are not about what pupils can observe in their environment. In addition, the point of reference of those learning activities is culturally and environmentally distant to the pupils. As a consequence, Ghanaian JSS pupils are likely to view school science as a body of concepts, scientific terms and facts which are to be learned, but have no personal or societal relevance. It is usually presented as reliable and authoritative knowledge. Much of such contents of school science are soon forgotten by the pupils.

In order to motivate and attract the interests of Ghanaian young learners in science learning, I argue for the Ghanaian physical and biological environments as entry point to science education. In that case, the indigenous knowledge systems which have bearing on science could be tapped as a way out to science teaching and learning.

Rationale for science and technology education at the junior secondary school

The fast advances in science and technology have influenced the rate of economic development of nations, improved the quality of life in most parts of the world, and provided solutions to some major problems and needs of societies. The impact of science and technology is felt on education, health, nutrition, transport and communication. Our continued existence depends on the mastery of the knowledge and attitudes of science and technology. For Ghana to develop there is the need to do away with allegory and false notion of natural phenomenon, and rather support the rapid development of scientific and technological literacy among all individuals. Since the JSS is a terminal point for the formal education of most pupils, it is at this point that scientific knowledge and attitudes need to be strengthened.

The general aims for science education at JSS level (see MOE, 2001; direct quotes from the teaching syllabus for science at JSS) are meant to help pupils to:

- develop understanding of scientific concepts and principles;
- develop an appreciation for the application of science to life;
- think and act scientifically;
- develop scientific attitudes towards life;

- understand the operation of simple appliances and gadgets used in everyday life;
- develop skills for producing simple gadgets and
- appreciate their environmental challenges and develop ways for conserving the environment.

2.4.2 Gender and Science and technology education in Ghana

In most rural African societies, women interact with the environment more than men do in the realm of agriculture and the tapping of other natural resources for domestic uses; hence women become the primary users of science in daily living (Avotri *et al.*, 2000). Therefore, science education for girls and women is a national asset for a developing nation in particular and any nation in general. Yet, Harding and Parker (1995) found in their research that everywhere, women are poorly represented in areas of employment that require science-related qualification, except biology and health-related subjects, like medicine and nursing.

Participation and performance in science education

At the compulsory education level (Basic Education), science education is compulsory. Therefore a low participation for girls in science education at that level may be as result of a lower enrolment number for girls in school or drop-outs. Girls are entering into science and science-related subject areas which hitherto had been perceived as the preserve of boys for many years. The present challenge is how to motivate, increase and sustain the interest of girls in science education and this has become an issue of concern within the Ghanaian educational system.

There are numerous studies confirming that boys have greater interest in many aspects of science than girls have, (see for example Clark, 1972; Mc Guffin, 1973 and Gardner, 1985 and 1998) with boys performing better than girls in most of the sciences (Avotri *et al.,* 2000). An available data in general science, taken at BECE for the period of 1995 to 1997 show that, there are gender differences in performance in favour of boys. The performance over the period in general science for boys and girls who obtained grades 1-6 are: In 1995, 80.6% of boys as against 73.7% of girls, in 1996, 76.3% and 69.2% of the boys and girls respectively. Similar pattern is seen in 1997, but girls showed some improvement in performance, 78.2% of boys as against 75.3% (Avotri *et al.,* 2000).

The gender gap in the choice of science and science-related discipline in Ghana is clearly seen at post-compulsory schooling, and this gap is most marked in physics in favour of boys. Scores from TIMSS 2003 test in Ghana indicated that the strong content areas in the science curriculum for the pupils were in chemistry and environmental science, while their weakest area was in physics, and that in all the five content areas, the boys achieved higher scores than the girls (Anamuah-Mensah *et al.,* 2004). However, TIMSS 2003 results for Ghana were not differentiated by urban/rural location.

2.4.3 Science education in schools in rural and urban settings

Webster and Fisher (2000) pointed out in their study that, pupils' attitudes towards and aspirations in science were affected by their access to resources. A finding linking attitude, achievement and access to resources was also supported by Barton (2001). She found from her study that urban Australian pupils were placed at disadvantage achievement-wise. According to her, urban schools were less adequately resourced.

Rural schools in Ghana may share many of the same challenges as schools in urban settings in western societies, with lack of funding and resources, aging facilities; and difficulty finding and retaining quality teachers is a commonplace in rural schools. A significant challenge facing schools in the rural communities, from the author's view point, is providing equitable educational opportunities. The perceived isolation of rural schools and a low population density create an additional set of challenges. Migration from rural areas to urban areas and cities has been the general trend in rural communities in Ghana, with rather a fast decline in population portraying a picture of slow death of the rural communities.

As a result of limited human resources and low income levels, community partnerships, and interest in schooling are often the case with rural schools. It has been indicated in a study of Zuniga *et al.* (2005) that a sense of isolation and low population density make opportunity fewer for pupils in rural schools. Furthermore, parents in rural communities may be unaware of options, prerequisites, secondary school and tertiary entry requirements and expected parental involvement in the schools. Parents who have no formal education or low educational achievement themselves are likely not to be aware of science courses their children should be taking if they have further educational aspirations. Also, in too many of our high poverty rural schools, students themselves appear to have no clear picture of what academic success looks like, and so they have very little chance of attaining it.

In a study on ‘commitment to equity, social justices and sense of place’ in urban science education in the US, Barton (2002) put forward a number of questions and concerns regarding urban school science education in a US setting. The concerns put up by Barton for urban science education appear to compare favourably with the science education in school in the rural area rather than the urban area school in Ghana. I will therefore allude to some of her ideas and as well limit myself to describe my own position on the situations in rural schools regarding science education in Ghana.

Science plays an important role in any society including rural and urban communities. The rural community that is always closer to nature needs a scientific knowledge base to involve in more informal conversations and debates on key environmental issues like water pollution, land and forest degradation, aside career opportunities. Though, rural pupils may exhibit excitement about science or science programmes, with given fewer opportunities to school science, might lead them to dislike science even more and that the ultimate result may be fewer chances for rural pupils to enter science-based programmes or compete for jobs in the science fields (Zuniga *et al.,* 2005; Coley, 1999). This is likely to lead to marginalization and perpetuation of a cycle.

Pupils in rural poverty in Ghana often have unequal access to the kind of science class, teachers, resources (such as textbooks and laboratory materials and equipments) and opportunities necessary for academic success in science as compared to pupils from urban or city. It is argued that the lack of these resources has a demoralizing effect on teachers to teach science (Fredua-Kwarteng and Ahia, 2005). This calls for a need to address the particular science education experiences of the rural youth. However, urban children from high-poverty backgrounds are also likely to lack access to opportunities to learn science even though they may have gained physical space and resources in school.

The attempt to examine the specific needs of rural learners alongside that of urban learners in outlining the inequities present in rural communities more or less appear to be limited. If it exists, it probably resides in the policy and planning sector, rather than in any orderly line of inquiry. But present and general trend in science education calls are 'science for all'.

2.4.4 Science and technology education and development

Education in general is seen as the most important factor for development. This is a fact, which has been highlighted by a World Bank statement that the economic returns to investments in education (as measured by productivity and income) are higher than these in physical capital and are essential to the successful investments in other sectors of the economy (World Bank 1990).

As mentioned earlier, science, in a broader sense, may be seen as the systematic study of nature. It includes the interactions between humans and their environment. There is therefore a natural inter-dependence between development of science and technology and the development of society. The progress and development of any nation depends largely on the quality of scientific and technological research. Education in science and technology are the most important areas of the curriculum to enable people to make sense of the world and to use the resources at hand (Sjøberg, 2002c). Science and technology education should therefore be given high priority in the school curriculum.

Development has at its core transformations in economic activity, living conditions and values that generate social change. Development draws on some combination of the ability to transform the physical environment, and changes in how groups of people choose to organise their ways of life (Lewin, 2002). Development may therefore be seen as both a technological advancement, a cultural and socio-economic shift to better conditions of life. The author of this thesis is of the opinion that science and technology education can play a vital role in contributing to development in Ghana. This is because in modern societies, education in science and technology has become the primacy of schooling, and is currently playing an increasing role in all realms of life.

In a world filled with the products of science-based technology, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day. Everyone needs to engage intelligently in public discourse and debate about important issues that involve science and technology. Scientific literacy is also a key issue in the workplace. Many of present jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems. A high quality of science and technology education can play a major role in contributing to these skills. Yet education [including science education] gets, according to UNDP report, a small share of the economy, especially in developing countries, and that the proportion of foreign assistance going into this area is rather small for most donors (UNDP, 1993-2005). Ghana as a developing country is not an exception to this phenomenon.

Globalisation and new technologies may be seen as changing ways in which production is organised and the characteristics of labour markets. Therefore, most countries are investing heavily to create scientifically and technically literate work forces. To keep pace in global markets, Ghana needs to have an equally capable citizenry.

The development of new information and communication technologies (ICTs) is having a tremendous impact on production and employment. Technological needs and market requirements will create demands, also in developing countries like Ghana, for highly skilled professionals who can provide ICT-based services competitively.

The *digital divide* between developed and developing countries is becoming an increasing matter of concern. This has implications for science and technology education in Ghana, because it clearly seen from the above observations that economic development is widely associated with advances in science and technology. However, the emerging globalisation and internationalisation may put pressure on science curriculum planners in particular and science educators in general to harmonize, standardize or universalise curricula and learning outcomes.

Application of modern technology in science education

A research finding on the application of information and communication technologies (ICT) in school science indicates a significant impact on learning (Mcfarlane and Friedler, 1998). Mcfarlane and Friedler found that learning was enhanced through the use of data logging.

Though, the replication of results of such study in a practical classroom situation in Ghana is meagre, the few examples found in well equipped science learning centres (science resource centres) in Ghana give credence to a possibility of an ICT-based science education. However, developing countries are confronted with a number of barriers in the use of ICT as a tool for achieving scientific knowledge. As a result, the use of ICT application in science lessons remains very patchy across the country. I identify these as infrastructural and digital (or computer) literacy barriers. The lack of access to computer and computer usage; lack of access to electricity, poor and unstable power distribution are examples of what I regard as infrastructural barriers.

Use of modern technology in science education in Ghana: Reality or mirage?

Ghana, in 1995, became one of the countries in sub-Saharan Africa to have access to Internet (Sulberger 2001 cited in Intsiful *et al*., 2003). However, Ghana continues to grapple with the provision of infrastructure facilities; such as science laboratories, books and equipments. But Ghana as a nation within the global village also sees it as equally important to position the educational system in such a way that it can empower the country to be part of the mainstream technological advancement in the world.

As a consequence, the government of Ghana has initiated a number of programmes to develop the ICT infrastructure so as to put Ghana in the mainstream of ICT. One of such programmes is the development of a national fibre optic network by the nation's electricity provider, the Volta River Authority (VRA) (Intsiful *et al*., 2003).

Yet ICT development is still in its infancy in Ghana. The costs of subscription and infrastructure are high, coupled with the poor quality of service by internet service providers (Sulberger, 2001). These are some of the major barriers to the use of ICT in science education and education in general. Information on classroom characteristics in the TIMSS 2003 indicates that in Ghana, though the national curriculum contains policy statements about the use of computers in teaching, on the average, computers were not accessible to a large number of pupils in schools who participated in TIMSS (Anamuah-Mensah *et al.,* 2004). In addition, most of the remote rural schools are not connected with the national electricity grid. The infrastructural barrier may be seen in a way to translate into the national level of or status in digital literacy; low level of computer literacy, limited access to Internet and computers. These challenges which appear to be common in most developing countries may widen the gap between the developed and the developing countries in ICT literacy.

The young learner may have high interest or fascination for the use of ICT in learning school science, the practical situation in the face of our economy may lower enthusiasm. Educational policy makers need to rethink how to make ICT more accessible within science education in this era of science for all in order to produce skilled work-force that can compete effectively in a globalized knowledge-based economy.

3. RELEVANT INITIATIVES IN SCIENCE EDUCATION

3.1 Introduction

Ghana, like many African countries, has accepted science and technology as a means to achieving socio-economic development. Science and technology education has been deemed to be an important aspect of the national programme for introducing science and technology into the country's development efforts. Therefore, both at the secondary and tertiary levels, capacities have been developed to ensure that the country has the high calibre of technical and scientific personnel needed for the achievement of its development objectives. However, to date the expected benefits from science and technology have not materialized compared with that of modern societies. This has been attributed partly to low investment in science and technology. Another important reason has been the low priority given to the place of basic science and technology education on knowledge in the community and workplace in generating interest and relevance (Anamuah-Mensah, 1998). Therefore graduates from the school system have little or no knowledge about the science and technology in and around their community. In order to promote meaningfulness, interest and relevance in science and technology education, there have been a number of initiatives both at national and international levels. The vision in general is to improve science and technology education.

3.2 Initiatives at the national level

Initiatives in science education are generally instituted to address some of the constraints that militate against science education in order to improve on the quality of science education delivery. As already mentioned, there have been a number of such initiatives to address the quality of science education in Ghana, especially the imbalance in access, equity and quality in science education between boys and girls; and also between rural and urban areas.

3.2.1 Initiatives by the professional science bodies

The Ghana Association of Science Teachers (GAST) and the Ghana Science Association (GSA) are the two major professional science associations on the local scene, whose activities are directed towards the improvement of science education. They come together differently to engage actively in the promotion of science literacy and the improvement of interests in and recruitment to science and technology education.

The GAST aims at promoting effective teaching in all pre-university institutions in Ghana through activities such as workshops, science content update and development of resources for science teaching. GAST does this in particular, by bringing science teachers in Ghana together to share ideas and promote the teaching of science in the schools. The educational reforms in Ghana have been of particular interest to the Association. The Ministry of Education has drawn up new science syllabuses in physics, chemistry, biology and integrated science for the senior secondary schools as part of the educational reforms. To assist the science teacher to feel comfortable in using the syllabuses effectively, GAST in collaboration with Macmillan Publishers Limited and Unimax Publishers has produced textbooks in the science subjects for senior secondary schools. These books are the product of extensive research by members of the Association to produce books that are Ghanaian in content.

The GSA coordinates research activity in both sciences and science education and promotes research in all branches of science. It is a voluntary and non profit making organization of scientists and technologists in Ghana. It is open to members of all other scientific professional associations in Ghana, such as engineers and medical practitioners. The main objectives of the Association are to encourage, promote and popularize the study and application of science and technology in Ghana. The GSA and the Council for Scientific and Industrial

Research (CSIR)[7] jointly publish the Ghana Journal of Science. The Journal is issued twice a year, in June and December.

3.2.2 Initiatives by AFCLIST at the University of Education in Ghana

Attempts to link school science to community knowledge of science and technology as well as that in the workplace in order to promote meaningfulness have been fragmented, lacking support in the form of curriculum materials and human resource. To address this issue, the AFCLIST[8] set up a centre of excellence at the University of Education at Winneba, Ghana in the year 2000. The acronym for the centre is SACOST -Centre for School and Community Science and Technology Studies. SACOST is seen as a Pan-African research and materials development centre for the promotion of community science and technology in African schools.

The vision of SACOST is to promote interdisciplinary research and development activities related to science and technology in indigenous, informal and formal manufacturing industries in order to improve science and technology education on the African continent. This is to be done through the establishment of networks across the region. As a centre of excellence, SACOST's mission is to cultivate relevant research competence, publication proficiency and quality knowledge for linking community and workplace science and technology with that of the school at the pre-university level.

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[7] The CSIR was established in October 1968 as a statutory corporation by a legislative instrument of the Government of Ghana. The council is mandated to undertake or collaborate in the collation, publication and dissemination of the results of research and other useful technical information in Ghana.

[8] AFCLIST (The African Forum for Children's Literacy in Science and Technology) is a Pan African science education project. It aims to develop the base for strong science and technology culture among young people in Africa and also for development of higher level human resources in science and technology. It is also the belief of the AFCLIST that, it is only through active participation of young people in their learning that can develop their confidence and ability to adopt and use the ever-increasing science-based that impinge on their lives. The Rockefeller Foundation and Norwegian Agency for Development and Cooperation (NORAD) are the major donors to AFCLIST.

The major activities of SACOST among others are:

- developing research and publication capability in the area of linking school science and technology with the community and workplace;
- documenting and analysing science and technology concepts and processes in indigenous, formal manufacturing and informal activities in the community;
- catalyzing and coordinating work by other researchers in linking school science and technology with that in the community and workplace throughout Africa; and
- developing multimedia teaching and learning materials; and approaches that link school and community science and technology.

3.2.3 Initiatives by the Government of Ghana

The government of Ghana, like many other African countries, has adopted science and technology as a vehicle for national development. It has developed a national science and technology policy document in line with the government's vision 2020. The basic objectives of the vision 2020, among others, is to seek to master science and technology capabilities, and to develop infrastructure, which will enable industry and other sectors of the economy to provide the basic needs of society.

The Ministry of Education’s vision for the future is patterned on the educational element of government’s vision 2020 (MEST, 2000). At the basic level, it is embodied in the programme for Free, Compulsory, Universal, Basic Education (FCUBE as the acronym). Examples of the aims of the education element of this plan are to provide an opportunity for every child of school going age in Ghana to receive good quality basic education by the year 2005, to increase the emphasis on scientific and technological education, and to make education more accessible to girls (MEST, 2000). The Ministry of Education is therefore to orient all levels of the country's educational system to teaching of science and technology.

To help lay a solid foundation for science education, science resource centres have been established throughout the country. These science resource centres are to serve all the secondary schools, especially the deprived schools, in the catchments area of each district. A resource centre is a well endowed secondary school selected in a district capital and well equipped with scientific instruments, computers and software on different science subject areas to enable secondary schools without well equipped science laboratory to have access to science practical work.

The Information Communications Technology (ICT) revolution is having tremendous impact on the rapid development of world economies and making national economies more interdependent than they were some years ago. The Ministry of Education is therefore committed to making Ghana a player in today's digital age. To this end, the Ministry has embarked upon a programme to streamline computer studies from basic schools. A curriculum has been developed for ICT training and examination at the Senior Secondary School Certificate Examination (SSSCE) Level. In addition, every effort is being made to provide telephone facilities to all senior secondary schools and training colleges to enable them benefit from the Internet connectivity.

The Science Technology and Mathematics Education (STME) clinic[9] for girls was instituted in 1987 to promote the interest of girls in science, technology and mathematics education. The clinic is intended mainly, to popularise science among girls and maximise the potentials of Ghanaian women with the specific aim of increasing and sustaining female participation in science, technology and mathematics (GES, 1998). The STME clinics have been extended to cover all the ten regions of Ghana, and further decentralized to cover all the districts in Ghana.

[9] STME clinic was established by the Girls Education Unit of the GES in 1987. The programme is termed a clinic because it is analogous to a hospital situation, where a problem is solved or a disease is treated through diagnosis and therapy. According to the Girls Education Unit of the GES, the identified “disease or problem” in this situation is the low participation of girls in Science, Technology and Mathematics at the higher levels of education. The diagnosis to find out the causes has emerged from research on girls, workshops, conferences of stakeholders in education, heads of institutions, teachers, parents and policy makers (GES, 1998).

During these clinics, female pupils get the chance of meeting and interacting with female role models who have made it in science and technology. They are given leadership training and also visit industries to acquaint themselves with the industrial process of production. This was to motivate and improve upon the number of girls pursuing science and technology related courses in our secondary schools as well as the universities.

In 1987, the Ministry of Education established the Girls Education Unit of the Ghana Education Service (GES)[10], purposely to serve the interest of the girl-child. The unit was tasked to increase girls' enrolment in schools to equal that of boys by the year 2005. It was also tasked to reduce the dropout rate for girls from 30% to 20% in the primary schools and in the JSS from 29% to 15% and increase girls choosing science and mathematics courses to equal that of boys (Atta-Quayson, n.d.). In addition, the Girl Child Scholarship programme began in the year 2001 by the Ghana Education Service. With the appointment of a Minister of State for Primary, Secondary and Girl-child education, awareness is being created among parents on the need to educate their girl-child.

3.3 Initiatives at the international level

3.3.1 Initiatives on African continent

African countries recognize the key role science and technology could play in its socio-economic and political development. This consciousness resulted in the first conference of African governments in Dakar, Senegal in 1974. According to Forge (1989 cited in Anamuah-Mensah, 1995), recommendations from this conference gave priority to the training of scientists and technologists to push the

[10] GES is the main implementing agency of the Ministry of Education for the pre-tertiary education. It develops comprehensive strategic plans along the educational policies of the Ministry and takes general oversight responsibility of implementation through its implementing units and divisions. GES, together with its implementing units and divisions work to develop their activities and initiatives around three

economic wheel of development in Africa and the revision of curricula at all levels to include science and technology. Following this, there have been a number of other similar conferences that have restated the importance of science and technology. Among these conferences is the Lagos Plan of Action, where African governments were urged to encourage the learning of science and technology at the basic level of education and use science as a means to development (OAU, 1981). The central role science and technology could play in the Africa's move towards development was also given recognition at the Harare Conference of Ministers of Education in 1982 and the Pan- African Conference on Education in 1984. The import of science and technology education to the development and in Africa's progress was touched at the then 47th Organization of African Unity Ministerial Conference in 1987 (Anamuah-Mensah, 1995). These initiatives are in collaboration with the effort of that of the World Conference on Education for All in 1990 with a declaration that suggests the close contact with contemporary technological and scientific knowledge at all level of education (World Conference on Education for All, 1990).

3.3.2 TIMSS

Many international initiatives are concerned with monitoring of conceptual understanding of science at school level. For example, the International Association for the Evaluation of Educational Achievement (IEA) conducted the TIMSS study aimed at measuring pupil achievement in mathematics and science (Martin *et al.,* 2004). They did so against a common standard 'TIMSS-curriculum' (Mullis *et al.,* 2003). They also assessed factors that influence the learning of those subjects. This large-scale comparative study, in which also some African countries, including Ghana, took part, did not directly address the issues of unsatisfactory recruitment to scientific studies and careers and low interest in school science. TIMSS focused on the understanding of the contents

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components including: improving quality of teaching; improving management efficiency; and increasing access and participation.

of science, mainly concepts, laws, models and theories and also tried to measure the understanding of the processes and ways of thinking that characterize science.

TIMSS and other international comparative studies, like the OECD's Programme for International Pupil Assessment (PISA) do, however, only to a limited degree measure attitudinal aspect of pupils' relationship to science and technology (OECD, 2004). TIMSS and PISA are important platforms for governments and ministries to focus on issues of performance or achievement measured against common standards. However, these studies are focussed on performance in cognitive domain to the neglect of affective domain. The adoption of the results of these studies by countries to draw up science curricula may lead to even a uniform or universal science curriculum (or science education). But there is the need for science and technology education that can promote gender equity, cultural diversity and take into account the views and values of the learners. Hence there is the need for other studies, to add equally important affective dimensions to the debate over science and technology. The ROSE-project which focuses more on pupils' attitudes, interests and out-of-school experiences, tries to fill this gap by providing another important alternative dimensions within the affective domain to the on-going debate over science and technology.

Ghana's participation in TIMSS

TIMSS 2003 seeks to monitor trends in science and mathematics at the eighth grade and at the fourth grade. Ghana participated only at the eighth grade (for Ghana; JSS2) level. Ghana's participation in TIMSS was strategic as it enables the country to find out how the performance of her eight graders (JSS) in science and mathematics compared with those of other countries.

TIMSS provided information on pupils' performance in mathematics and science as well as their attitudes towards these two subjects. At the same time it provided information on contextual factors such as home environment, curricular intentions and classroom environments, which have the potential of influencing their performance. The participation in TIMSS provided the opportunity to examine pupils' achievement in mathematics and science using an international yardstick and to compare this to that of other countries both within and beyond the continent of Africa.

A total of 5114 JSS 2 (eighth grade) pupils from 150 schools sampled across the country took part in the TIMSS 2003. The JSS 2 pupils in the sample were made up of 45 percent girls and 55 percent boys. Ghana performed very poorly that it ended in the 44th position among 45 countries that participated in the test. The overall performance of Ghanaian pupils on the mathematics and science test was poor, placing them on average scores of 276 in mathematics (International average is 466) and in science 255 (473) respectively. These two scores placed the nation second from the bottom for the two subjects on results table (Anamuah- Mensah *et al.,* 2004).

The mean percent correct on all science test items for each participating pupil was 19% (averagely, each pupil obtain only 19% of the items correct). The performance of all pupils is also described in terms of international benchmarks[11].Only 13% and 3% of the pupils reached the low and intermediate international benchmarks respectively. The pupils' strong content areas in the science curriculum were in environmental science and chemistry, while their weakest area was in physics. Over 80% of the pupils not reaching the low international benchmark imply that the majority of these pupils have poor knowledge of basic science facts and grasp of science concepts and enquiry skills which are lower level cognitive competencies (Anamuah-Mensah *et al.,* 2004).

[11] TIMSS 2003 mathematics and science achievement scales summarise Year 8 pupils' performance on test items designed to measure a wide range of pupil knowledge and understanding. Four points on each scale were identified for use as international benchmarks. The performance of all pupils in all countries which participated in TIMSS 2003 was taken into account when defining these benchmarks, which are described as follows: Advanced International Benchmark corresponds to a scale score of 625; High International Benchmark is 550; Intermediate International Benchmark is 475; and that of Low International Benchmark is 400.

Although there are some contextual variables which correlate positively with achievement (variables such as socio-economic status, classroom environments, geographic location and language), affective dimensions are to be seen as major determinants in learning.

3.3.3 The ROSE Project

The ROSE study is an international project with about 40 participating countries. ROSE is organized by Svein Sjøberg and Camilla Schreiner, at The University of Oslo and is supported by the Research Council of Norway. Reports and details of the ROSE questionnaire and information about countries involved are found in Schreiner and Sjøberg (2004) and also available at web site (http://www.ils.uio.no/forskning/rose/).

The above sources look at the issues of technicality and methodology regarding rational, design, piloting and deployment of the ROSE questionnaire, including reliability, validity and the use of Likert scale. In chapter 5, I will consider some of these issues in more detail.

The ROSE project is a cross-cultural comparative study, where a common instrument has been used to collect information from 15 year-old cohorts. Key international research institutions and individuals including the author of this thesis have worked jointly on the development of theoretical perspectives, research instruments for data collection and analysis.

The objectives of ROSE project among others are to:

- develop an instrument to collect data on pupils' experiences, interests, priorities, images and perceptions that are of relevance for their learning of science and technology (S&T) and their attitudes towards the subjects;
- collect, analyse and discuss data from a wide range of countries and cultural context using the instrument referred to as ROSE-instruments;

- develop policy recommendations for the improvement of curricula, textbooks and classroom activities base on the findings above.

The ROSE project has the ambition to provide theoretical insight into factors that relate to the relevance of the contents as well as the context of science and technology curricula. It is also not to be seen as competing with other studies like TIMSS and PISA or interest in comparative science education, but rather as a contribution to the on-going debate about curriculum priorities by providing empirical evidence on other dimensions than those addressed by TIMSS and PISA.

Ghana's participation in ROSE project and the GRASSMATE project

It is worth noting that, the University of Education of Winneba, Ghana, is one of the international research institutions on the on-going ROSE project. The University engaged me as a resident coordinator for the ROSE project and also a candidate scientist to work towards a PhD based on that project in the GRASSMATE (Graduate Studies in Science, Mathematics and Technology Education) project.

GRASSMATE project is a research capacity building project, which was launched in 2002 with 22 students from ten sub-Saharan African countries, including Ghana. The project adopted two major aims:

- the pursuance of a doctoral degree (PhD) by individual students;
- the building of a network within science and mathematics education across sub-Saharan African countries and other countries, in particular Norway.

The project is an initiative funded by the Norwegian Ministry of Foreign Affairs. The University of Bergen, Norway; and the University of Western Cape, South Africa coordinate the GRASSMATE project. The detailed information on the GRASSMATE project is available at web site (http://www.uib.no/people/pprsk/GRASSMATE/index.htm).

The methodology in this thesis is primarily based on the considerations and the instruments of the ROSE project. I have therefore adhered to the objectives of ROSE project. Among the objectives are:

- to collect, analyze and discuss data from a range of countries and cultural context using the instruments referred to as ROSE instruments;
- develop policy recommendations for the improvement of curricula, textbooks and classroom activities based on the findings.

4. LITERATURE REVIEW

4.1 Introduction

The ROSE project, on which this thesis is based, aims to explore some affective qualities of science teaching and learning, and also to stimulate discussions about context-based science curriculum. This chapter reviews literature based on affective dimensions of science teaching and learning (such as attitude, belief, perception and interest related to science education). The research literature on studies of such aspects is rich and abounds in the developed countries. All science education journals continue to publish such articles regularly. Some of these are mentioned in this chapter. The more I dig into the literature about affective factors of science teaching and learning, the lesser becomes such studies on the Ghanaian scene and that of Africa in general. Thus we do not have many Ghanaian and also African studies of such aspects. Also comparisons of interests in and attitudes towards science education between African countries and other parts of the world are missing. There is, at least, an obvious gap to be bridged here. This study hopes to address that.

Some current issues within science education are also discussed. Current issues of gender, out-of-school experience, environmental issues, future career path and socio-economic status of parents in relation with science education are touched in this chapter. Finally, the social constructivist ideas about learning relating it to affective factors are discussed.

It is important to note that an affective dimension of learning, such as attitudes formation, is dynamic and could change with circumstances. The findings from such studies may not be applicable with the passage of time even in the areas where studies were undertaken. However the reviews of literature in this study, on the affective dimensions in relation to science learning, are meant to guide and inform my discussion of the results of this study.

4.2 Some studies in the affective dimensions of science education

Schreiner and Sjøberg write:

> *Much of the actual contents of S&T in schools are soon forgotten by the pupils. But it is likely that the attitudinal outcomes have a more lasting effect. Pupils who develop an interest for science at school are likely to pursue such interests later in life. And pupils who learn to hate science and mathematics at school are likely to avoid these subjects through their life. Affective factors are therefore important determinants for the choice of school subjects and future careers. It is worthwhile to note that investing in attitudes is investing in the future (Schreiner and Sjøberg 2004: 18).*

Due to the primacy of the affective, research into the affective factors relating to science teaching and learning has attracted the attention of science educators for sometime now (Gardner, 1985; 1995; Shrigley, *et al.,* 1988; Ramsden, 1998). According to Ramsden (1998), many teachers consider pupils' attitudes and interests and how to make the pupils feel more positive about their science lesson as the most pressing area of research in science education.

There are several science education studies that concentrate on the pupils' alternative conceptions in science (see Duit, 2004). In these studies, researchers have found that school science learners hold ideas about science that are sometimes different from those of accepted science and hence in school science. However, there are not many studies that address the attitudinal aspects of pupils' relationship to science and technology. Nevertheless, reviews have been published (e.g. Gardner, 1998; Osborne, Simon and Collins, 2003). A cross-cultural study, Science and Scientist (SAS) study has focused on 21 countries of over nine thousand 13-year-old children's interest in science and their attitudes to science and scientists (Sjøberg, 2000a, 2002a).

A more recent and extensive international comparative survey of 15-year-old pupils' views of science and science education, ROSE project, has been initiated and some preliminary findings are reported at the 11th IOSTE Symposium (Schreiner and Sjøberg, 2004) and other sources (see for instance, Jenkins and Nelson, 2005; Jones *et al.,* 2000). The present thesis is part of the ROSE project.

4.2.1 The concept of attitude

Curtis (1926) played a pioneering role of introducing the concept of attitude from social science to the field of science education. Since then, the concept of attitude has attracted various definitions and explanations in many areas of learning including social psychology and the social sciences. Attitudes are complex and difficult to measure (Page-Bucci, 2003).

Attitudes towards science may be used to refer to as general and continuing positive or negative feelings about science. Though there might be interrelationship between beliefs, attitudes and behaviour; attitudes towards science may be viewed as a convenient summary of a wide variety of beliefs about science, which in turn permits the prediction of science related behaviour. The term belief might therefore, be referred to as the information that a person accepts to be true.

Scientific attitudes imply certain ways of thinking and certain ways of approaching problems. It also implies an attitude of wanting to find explanations that are secular and do not refer to authority (Schreiner and Sjøberg, 2004). In contrast, *attitudes towards science* may be viewed as a wide variety of beliefs about science. Though, *scientific attitudes* are considered important outcomes from science and technology in schools, the focus of the thesis is more on *attitudes towards science.*

4.2.2 Some determinant factors of attitudes formation

Attitudes towards science and their formation are often scantily expressed and not well understood. Probably, our understanding of the nature of this problem might have been better; however, our understanding of its remediation may be missing. As a consequence, some arguments have been raised for a research focus on attitudes towards science (Osborne, Simon and Collins, 2003).

Earlier studies on pupils' attitudes to learning and what pupils learn were found to be greatly influenced by how they are taught. Pupils will be unable to receive enough science learning experience when school teachers themselves are not pleased with science teaching (Simpson and Oliver, 1990). The significant role that teachers play in pupils' attitudes formation towards subjects has been confirmed by a number of studies; notable among them are that of Ebenezer and Zoller (1993) on attitude towards science with American grade 10 pupils of ages between 15 and 16, and the work of Sundberg *et al*. (1994), who studied the attitudes towards science of 2965 United States college pupils. Hendley *et al.* (1995) conducted a small-scale qualitative study in the United Kingdom on Key Stage 3 pupils' preferred subjects and found that teacher-related comments surfaced as of most reasons for liking or disliking a subject. Similar outcomes have been reported by Atwater and her colleagues in a study in the United States. They found that pupils' attitudes towards science are significantly influenced by how they perceived their science teacher and to a lesser extent by the science curriculum (Atwater, Wiggins and Gardner, 1995).

Though, teacher-attitude has been cited by several studies as an important determinant in attitudes formation, the classroom environment also plays a significant role in attitudes formation (Simpson and Oliver, 1990; Myers and Fouts, 1992; Piburn and Baker, 1993).

A sample of 699 pupils from 27 high schools in America, through a study conducted by Myers and Fouts (1992) established that the most positive attitudes were associated with high level of involvement, very high level of personal support, strong relationships with classmates, and the use of a variety of teaching strategies and unusual learning activity. A strong support for this finding comes from the work of Piburn and Baker (1993) who, interviewing pupils comprising 83 elementary school pupils, 35 junior high school pupils and 31 high school pupils in the United Kingdom, identifies the classroom environment as one of the major factors in interest generation in science education. Similar conclusions that classroom environment has influence on attitudes towards science were drawn from a major longitudinal study conducted in North Carolina (Simpson and Oliver, 1990).

Teaching method has also been cited as one of the strongest influence on pupils' attitudes towards science. Evidence has been provided by Woolnough (1991), that the quality of teaching of school science is a significant determinant of attitude towards school science. A review of Woolnough's work according to Osborne *et al.* (2003), revealed six factors that were responsible for pupil choice or non-choice of the sciences. The two strongest factors were the influence of pupil's positive experience of extra-curricular activities and the quality of the science teaching. It has also been identified that, all teachers in that particular work know that the teaching method or the pedagogy does indeed make a difference (Reiss, 2000; Osborne and Collins, 2001).

Attitude of peers and friends is found to be another significant factor which determines attitude towards science (Breakwell and Beardsell, 1992). An earlier study by Simpson and Oliver (1985) indicates a peer group influence which exists in relationships among peers increase from age 11 onwards, peaking at age 14. This is a period, where often subject choices are about to be made and also where individual attempts to assert self-identity.

4.2.3 Pupils' attitudes and beliefs

Attitudes and beliefs of pupils are of importance for their learning of science. Pupils always develop some sort of idea about what science is all about, how scientists are as persons, what they actually do and how this relates to society, the environment and the lives of themselves and other people. But pupils' ideas about the nature of science, the personalities of scientists and the purpose and meaning of their activities may have different sources (see for instance the SAS-study, Sjoberg, 2002a). They may emerge from out-of-school influence, or encounter with school science and the science teachers (Atwater, Wiggins and

Gardner, 1995). Some ideas may arise from their own culture. These may influence the pupils’ eagerness, motivation or interest to learn science.

According to Alsop and Watts (2003), learning involves moving from the familiar to the unfamiliar, traversing the emotional quagmire of success, self-doubt and challenge as well as classroom identity. Despite the widespread belief that emotions are a central part of learning and teaching, work in science education exploring affect is still insufficient.

Many reasons have been given: A long-standing cognitive tradition of science education research and intense scrutiny under which methodology in the study of affect is subjected to, is given by Alsop and Watts (2003) as one of the reasons. Jenkins and Nelson (2005) have also identified two reasons. According to Jenkins and Nelson, firstly, it may be the reflection of both the academic background in the natural sciences of many science education researchers. Secondly, the assumed difficulty of accommodating the pupil voice in the curriculum that continues to put emphasis on science as a body of established knowledge to be learnt.

In a number of cases, attitudinal studies in science education research have often been driven by the disturbing trend in the decline in pupils pursuing post-compulsory science education, especially, in the developed economics (Jenkins, 1994; Lepkowska, 1996). However, recently there has been proliferation of studies on pupils' attitudes towards science, as well as reviews on such studies (Mathews, 2004; Osborne et al., 2003; Jones et al., 2000; Simons, 2000; Ramsden, 1998). These give support to the importance of attitudinal studies in science education research.

Earlier than these, however, the conclusions drawn from some of the studies appear to be consistent in findings, but the results have not been conclusive (see for example, Ramsden, 1998; Gardner 1995; Schibeci, 1984). Krogh and Thomsen (2005) also supported this observation and commented that in most cases, variables such as personality, classroom and structural variables have been separated and discussed in isolation from conclusions, as one of the reasons for which attitudinal studies lack conclusiveness in results.

Whatever the explanations may be, pupils leaving with attitudes of any kind are likely to influence the use of knowledge, competencies or skills acquired from science class for purposes of career choice, democratic participation and participation in debate on scientific issues.

4.2.4 Pupils' interests in science education

Teaching, learning, and curriculum development, in which personal and contextual relevance are considered are key educational concerns (Sjøberg, 2002b). This implies that personal and societal interests are to be seen as key factors for engaging in science education. Hence science education is to portray science as Aikenhead (2003) refers to as a 'personal-curiosity science'. This is in contrast to the 'readymade' science of school textbooks and classrooms with which most adults across cultures have had some contact. This textbook science is often criticised for its lack of relevance and deeper meaning for the learners and their life, and that the content is frequently presented without being related to social and human needs (Sjøberg, 2002b).

According to Aikenhead, the personal-curiosity science concerns pupils themselves deciding school science topics from their peculiar interests and desire. Sjøberg and Schreiner (2005a) allude to the fact that the economical significance for a country to have a high number of skilled scientists and engineers is well accepted. But young people do not choose their studies or careers because it is good for the economy of their country, especially for a country where young people have such choices. They do so based on their own interests, values and priorities. It is therefore important that school science education reflects this if it is to adequately prepare school leavers for the society they are entering.

Rutherford and Ahlgren (1990) also revealed that the content and practice of science education have not been connected with pupils' interests and experiences, leading to a sense of its irrelevance to their lives. A consequence of this is that school leavers may be ill-prepared by their school science education for personal decision making on the many controversial societal issues that continue to raise public debate and concern. However, a more interesting school science can lead to more motivation, engagement and participation (Schreiner and Sjøberg, 2004). The pupils will need to be strongly motivated and sense that they are learning something worthwhile, interesting and valuable to them.

Some topics of interest to the learners

Research literature on interests, despite the different approaches in methodology provides some findings which appear to be valid across a number of educational systems and cultures (Schreiner and Sjøberg, 2004). The SAS study (Sjøberg, 2000b, 2002a), for example, revealed a considerable difference among the pupils from different countries in what they were interested in learning about. Sjøberg found low overall interests in Japan. But pupils from developing countries seem to be interested in learning about nearly everything. In general pupils from developing countries were found to be far more interested than pupils from more economically developed countries. The gender differences in developing countries were less pronounced as compared to other industrial countries, but to some varying degree.

There are numerous studies showing that boys have greater interest in science than girls. The nature of boys' and girls' interests in science also tend to differ, with boys relatively more interested in physical science and girls more interested in biological and social science topics (Clark, 1972; McGuffin, 1973; Smithers and Hill, 1987).

When the science is broken down by discipline, the situation looks even less promising in the physical sciences for girls. Several studies (for instance, Hoffmann, 1985; Dawson, 2000; Osborne and Collins, 2001; Colley *et al*., 2003) have also confirmed the tendency for boys having significantly higher preferences in physics and technology subjects, while girls' preference is more of biology.

Girls' lack of interests for physics can, however, not be generalised for all topics in physics, there are some topics that appeal to girls. Osborne and Collins (2001) found among young English pupils that, girls did not share the boys' interest in the physics related to cars and flight, but that they expressed some interest in light and electricity.

In particular, that of Hoffmann's (1985) study showed that interest in physics is progressively decreasing for boys and girls with increasing age, but for girls much more significantly. The ROSE study does not focus on age as a variable and therefore becomes irrelevant for this thesis. This means I will not pursue any further discussion on age as a factor of influence.

A review of recent studies in science education appears to indicate pupils' preference for a science curriculum that includes socio-scientific issues and teaching methods that includes discussion. One conclusion drawn from a web-based survey collecting data from 1500 English pupils between the ages of 14-15 years about the pupil review of the science curriculum, according to Cerini *et al.* (2003) was that: the pupils would have preferred a science curriculum which includes more contemporary socio-scientific controversial issues as well as more philosophical and ethical matters. It was also found that the overall interests shown by pupils were high in topics which were suitable for discussion and deliberations, while fact-oriented topics had less appeal.

Earlier findings from studies of Osborne and Collins (2000; 2001) and Jarman and McClune (2002) of UK pupils indicate the pupils' interests in socio-scientific issues that bother on many political and ethical controversies such as matters of environment, gene technology and population growth.

4.2.5 Gender and science and technology education

Girls and women have a long history of under-representation in science and technology studies and careers that continue to this day (see for example, Kahle and Meece, 1994; Rennie *et al.,* 1996; Jovanovic and King, 1998; Osborne *et al.,* 2003). The issues associated with the under-representation of girls and women in science and technology-related studies and careers are complex. Many different groups of people have assigned different reasons to and with different agendas and priorities about the low participation of girls and women in science and technology (Sjøberg, 2002c). Cultural practices, poverty, masculinity in science education and possible bias in scientific knowledge have been cited through feminist critique of science and science education as some of the reasons for under representation of girls and women in science and technology (see for instance, Sinnes, 1998; 2002, Barton, 1998).

Poverty, for example, has been observed as one of the single factors that affects girls'participation and performance in science in Africa as it prevents many girls from having access to any scientific education. However, Sinnes (1998) has also observed that in developed countries where girls and boys are not affected by poverty, low participation of girls in science is still experienced; and that even in the highly developed countries where girls and boys have equal opportunity to study science, there are significant differences in both the participation, performance and interest in science education. Hence it appears there are other additional factors, beyond the more obvious practical hindrances, that militate against girls' access to science education. The complex nature of the issues even appears to start with the concept of gender.

The concept of gender

The term 'gender' has emerged to replace 'sex' in the educational and social science studies for some time now. There might be many reasons attached to the shift to the use of term 'gender'. Perhaps, gender is often used euphemistically in many studies to avoid the negative connotations of the word 'sex'.

It appears 'sex' seems to connote the unwanted sexual idea while 'gender' does not. Also 'sex' directly refers to the *biological* classification of people while 'gender' refers to the social nature of the issue. However, both are important analytical tool though, in the context of males, females, and science, the 'gender' is now frequently used. According to Sjøberg (2002b), the distinction between sex and gender also indicates that femininity or masculinity are not biologically determined, but are socially constructed or negotiated, and that they may change over time and may be different from one culture to another. For this study, gender is used whenever there is a discussion on differences between male and female on any aspect of science learning.

Gender differences in interests and attitudes towards science education

As already mentioned, girls and women constitute more than half of the world's population and of the total burden of work, women carry on average 53% in developing countries and 51% in industrial countries (UNDP 1995, p. 6). But when it comes to education in general and science and technology education, girls and women have the lowest access.

A proliferation of research literature in science education reports of boy/girl differences in interest in many aspects of science. Boys tend to have relatively more interest in physical science and girls more interested in biological science topics (see for example Kahle and Meece, 1994; Anamuah-Mensah, 1995; Rennie *et al.,* 1996; Jones *et al.,* 2000). For instance, in Ghana, girls' enrolment in physics, chemistry and additional mathematics is far lower than in biology. One suggestion has been that biology appears to be perceived by pupils as being less mathematical and therefore, easier to learn (Anamuah-Mensah, 1995). A study of gender differences regarding science learning involving a total of 437 sixth grade U.S. students reported that, more females than males perceived science as difficult to understand, with a reason that science involves experiments (Jones *et al.,* 2000).

Sjøberg (2002c) also confirms that from a gender perspective, biology in particular is more popular among girls; chemistry does not show a clear gender profile. On the other hand, physics which appears more mathematical is the most problematic for both boys and girls, but less among girls. In the same report and with respect to achievement in science, gender difference follows a similar pattern.

According to Sjøberg, boys as a group show a higher achievement in physics. In chemistry difference is found to be smaller, but in favour of boys. However, achievement in biology shows more equal pattern, with some parts of biology favouring girls. For example in the SAS study, girls in all countries are found to be more interested than boys in learning about health, nutrition which are some aspects of biology (Sjoberg, 2000b).

Rutherford and Ahlgren (1990) have argued that the content and practice of school science have not connected with pupils' interests and experiences, leading to a sense of its irrelevance to their lives. It can be argued that one consequence of this is that favourable attitudes towards and interests in science are probably eroded by the experience of school science.

Many reasons have also been assigned through numerous studies to the differences in attitudes towards science and interests in science between girls and boys. The studies have attributed the low female participation and performance in science and technology education to a number of factors. The factors include socio-cultural, societal expectation and educational practices.

Hutt (1972) showed that gender differences in attitudes towards science arose relatively early in life. This early socialization, which Kelly (1981) called 'the cultural theory', may lead girls away from science. Later, Murphy (1990) also pointed out in a study that early childhood experience plays a vital role in shaping a child's interest and self-image. The Ghanaian society is impregnated with traditional norms and values that dictate the roles and activities of the two sexes. These norms and values, according to Anamuah-Mensah (1994) tend to affect the psychological make-up of both sexes.

Some of these studies have gained interesting insights, however research-based knowledge of the structure and nature of the science course in the early secondary is still insufficient in Ghana, and one cannot simply take studies in other cultures and assume they are valid also for Ghana. If we want to design relevant curriculum material for science education for all, we need knowledge about what interests both boys and girls in order to construct a balanced curriculum. Girls are different from boys, and therefore, science needs a variety of perspectives to appeal to both boys and girls. One has to take into account well documented personality differences of girls and boys: girls are, in most cultures, socialized to become more person-oriented, socially responsible, cooperative, while boys tend to be more independent, achievement-oriented and dominant (Smithers and Hill, 1987).

Science has traditionally been taught in a male-oriented way, and hence it appeals more to boys than to girls. In Ghana, for example, there have been major changes in the educational scene since independence in 1957, but with little sign of stability. There have been repeated modifications of the science curriculum, which appears not to have focussed enough on the structure and nature of boys' and girls' interests separately in science curriculum. Many developing countries had to adopted school systems, curricula and textbooks derived from the colonial power (Anamuah-Mensah, 1998). This has given credence to long existing science learning that we may label traditional school science. Evidence-based criticism of traditional school science has been its lack of relevance for everyday world (Osborne and Collins, 2000 and Reiss, 2000).

One of the important goals of this study therefore is to identify interesting science content knowledge for gender-inclusive science education within the compulsory school level in Ghana.

4.2.6 Children's out-of-school experiences

There is a general acceptance that all teaching should 'build on' the interest and experience of the child. It must have some sort of relevance, and it must fit into the personal curiosity or societal context of the child (Sjøberg, 2002a). Yet in most countries there is a considerable gap between what is learned in the classroom and the real life context of the pupils' present or future world (Anamuah-Mensah and Towse, 1995; Stevenson, 1995 and Muskin, 1997, cited in Towse *et al.,* 2005). But the simple and obvious fact is that children are different. They do not have the same experiences when they meet school science, nor do they have the same interests. There are differences between pupils in the same class, in the same school or same nation. And there may be systematic differences between girls and boys. And there are large differences between children in different countries (Sjøberg, 2002a).

Not only do experiences and interests among the learners vary. It is also evident that there are similar variations in what can be said to be 'relevant' and useful knowledge for children coming from such different life situations. Learning to cope with the daily challenges and preparing for a meaningful life varies according to the different backgrounds of the children. Researchers continue to shed light on girls' and boys' prior science-related experiences, and have documented those experiences revealing that boys and girls are not the same over childhood and adolescence (Jones *et al.,* 2000; Baker and Leary, 1995; Kahle and Lakes, 1983). For example, Kahle and Lake (1983) reported different out-of-school experiences in science for boys and girls. According to Kahle and Lake, more boys than girls have indicated visiting a factory, a weather station and that more boys further showed that they read science articles and watched science television shows. Baker and Leary (1995) interviewed girls in grades 2, 5, 8 and 11 in the U.S. about what influences girls to choose science. It was found during the interview that girls with positive attitudes towards science attributed their attitudes, in part, to extracurricular experiences such as doing science at home, reading about science, or watching science-related television programmes. In the same sample, Baker and Leary found that girls preferred biological sciences to physical sciences because they viewed biological sciences as areas where they can give help or care more for people, animals, or the earth. Jones *et al.* (2000) showed from a sample of 437 sixth grade of U.S. pupils that more males than females reported prior experiences out of school with a variety of tools and objects, including rifles, batteries, electric toys, fuses, microscopes and pulley. In contrast, more females than males reported prior experiences such as bread-making, observing birds and stars, knitting, sewing, and planting seeds. The findings noted above show stereotypic gender differences that boys tend to have more experiences in or preference for physical sciences as girls tend to prefer biological sciences.

A body of research suggests that learning canonical science content meaningfully is simply not achievable for the great majority of pupils in the context of traditional school science (see for example, Aikenhead, 2003; Shapiro, 2004). However, it seems to be achieved to some extent in out-of-school context, where people are involved in science and technology-related everyday issues (Davidson and Schibeci, 2000; Dori and Tal, 2000; Wynne, 1991). It has also been observed that most often, canonical science content is not directly useable in science-related everyday situations (Furnham, 1992; Layton, 1991; Solomon, 1994). Furthermore, the criticism that has been levelled against traditional science is its lack of relevance for the everyday world (Osborne and Collins, 2000).

The various findings from this corpus of study appear to reveal that more often than not, learners are likely to import their diverse worldviews into the science classroom. Yet studies that have been carried out to investigate the link between school science and out-of- school experience appear to be meagre. However, Towse *et al.,* (2005) have identified some problems associated with how to link what is learned (for example science) in the classroom and real life context of pupils, which for them, is particularly true of the less-developed countries. According to Towse *et al.,* part of the problem lies in the fact that teachers have limited experience of 'life outside the classroom' and no access to resource materials through which to emphasise relevance. Additionally, for them, part also lies in the extent to which most curricula are examination-driven, in consequence teachers espouse a 'chalk and talk' approach most often to cover the curriculum and meet the expectations of pupils, heads of school, parents and most notably, politicians who judge educational success merely in terms of results.

4.2.7 Science education and environmental challenges

The present generation of young learners is growing at time that the earth faces numerous and different types of environmental degradation as a result of humans' engagement with nature. The current challenges in environmental protection strategies require the full participation of all citizens, but not to be seen as responsibility of only scientists, politicians and researchers. The citizenry must be aware and well informed about the values of sustainable environmental practices. An important outcome of science education is to have pupils make informed decisions about and take informed actions on personal lifestyle choices, local challenges, global changes, risks and benefits, and populations, resources and environments (NRC, 1996). Science education has a key role in preparing young people to cope with the emergent environmental challenges. Therefore environmental education, which appears to becoming a part of science education programmes currently, might help in the development of individuals to demonstrate responsible environmental behaviour towards their environment in order to develop a sustainable environment.

However, the environmental practices go far beyond acquisition of environmental knowledge based on scientific ideas and concepts (cognitive factors), but must also relate to affective dimensions, such as environmental attitude, concern, beliefs, values and emotional disposition (Schreiner and Sjøberg, 2003). This suggests that prior knowledge as well as value, beliefs, attitude, concern and emotional disposition of learners might influence their understandings about and capabilities to act towards the environment (Huang and

Yore, 2003). Teaching needs therefore to be based on pupils' knowledge, attitudes towards and conceptions of the environmental protection issues.

Some studies in environmental education

Empowering learners to be responsible towards the environment should be one of the important goals of science education. Unfortunately, much attention of science education researchers have been drawn into studies in pupils' alternative conceptions of science content to the neglect of pupils' perspectives regarding environmental matters (Schreiner and Sjøberg, 2004; Reid and Sa'di, 1997). However, attempts have been made in this direction for some time now.

Schreiner and Sjøberg (2003) conducted a study on how young people relate to environmental challenges with 1200 15-year-old Norwegian pupils as part of ROSE and found from preliminary analysis that pupils did not seem pessimistic about the global future. They trust in themselves that they personally can influence what happens with the environment. The study also confirmed the pupils' general concern about the environment but that they showed low interest to learn about environmental protection at school.

However, it seems there are no notable gender differences regarding environmental issues. A study in the United Kingdom with elementary school children with ages between 11and 13 years, all indicated positive attitudes towards nature and the environment. They also identified pollution, deforestation, and extinction of species as some of many problems confronting the earth, and accepted the individual responsibility for the environment and not others or the government (Bonnet and Williams, 1998).

It appears environmental issues are a cross-cultural concern. For example, the environmental views of 12-year-old German and Russian adolescents were investigated and it was found that adolescents from both countries showed high emotional dispositions towards environmental problems (Szagum and Pavlov, 1995).

Results from a comparative study of grade 5 children from Canada and Taiwan revealed that children from both countries expressed positive environmental behaviour, positive attitudes towards the environment, high concern about the environmental problems, high emotional disposition towards current environmental situations and moderate environmental knowledge (Huang and Yore, 2003). In the entire studies, affective variables appear to feature strongly to influence children's responsible environmental behaviour than the cognitive variable. For example, the Science And Scientists (SAS) study investigated 13-year-old pupils about what they would like to learn about in school science lessons, environmental topics scored below average interest among pupils in most Western countries (Sjøberg, 2000b, 2002a).

4.2.8 Science education and future career path

One of the key aims for science education is to prepare pupils for science-related careers in, for example, medicine, engineering, industry and teaching professions (MEST, 2000; Aikenhead, 2005). It is the anticipation of science curriculum developers in general that pupils are able to incorporate scientific content into their own thinking so that this content is made available later in the science-related world of work (AAAS, 1989, cited in Aikenhead, 2005). However, it appears there is universality about the perceived mismatch between educational outcomes and the needs of the world of work. This has also been shown in some research studies in science education pointing to the fact that, in general, there is a pitiable match between the scientific content taught in school and university science courses; and the type of scientific understanding necessary for success in science-based occupations (Duggan and Gott, 2002; Coles, 1997). The awareness paid to developing pupils' reasoning abilities, expressiveness and creativity or ingenuity, if any, is scant (Muskin, 1997). This problem may be at different points on the scale, African countries are running in parallel to the more developed regions of the world; and there are more similarities than there are differences (Jevons, 1973, cited in Towse *et al*., 2005:2). According to Anamuah-Mensah and Towse (1995), in most countries, especially in the less-developed countries, there is a considerable gap between what is learned in the classroom and the real life context of the pupils' present or future world.

Nevertheless other studies elsewhere have indicated that some factors are considered by pupils when decisions on career choice or path are made (see for example, Baker and Leary, 1995; Shmurak, 1998; Lewis and Collins, 2001). For instance, Baker and Leary (1995) and Shmurak (1998) have both found that girls in each of their studies selected science-related careers based upon a desire to help people, animals, plants, and the earth. It is obvious, therefore, that careers in the physical sciences continue to be beset by negative stereotypes. When pupils value helping others, they are not likely to have desire for careers in physical science (Eccles, 1994), however, according to Eccles there are numerous physical science careers that allow the individual to help others, especially in chemistry, computers, and engineering.

Furthermore, in most countries, it is a general observation that females are poorly represented at the decision-making positions in many job areas despite the equal academic qualifications and work experience with the male counterpart; and the top positions often are male-dominated (Twshene, 2003). According to Schwedes (2005), a report on professional instruction of the German Ministry of Education indicated that most girls still concentrate their choice of job on a too small variety of occupations which are moreover typical female. Schwedes further showed that in 1988, for example, more than half of the girls starting a vocational training chose to become hairdressers, doctors' assistants or saleswomen and less than five percent indicated a profession in science or engineering, excluding medicine. These situations are similar to that in Ghana and most developing countries.

In their study, Lewis and Collins (2001) observed that some participants altered their career paths and concluded that those participants may have perceived their more recent choices as more relevant to their lives and their long-term goals; and having a more direct application or relevance, or as being more interesting.

However, it is also important to note that an individual's choices are likely to be inadequate in the knowledge one possesses about the existing possible job options. A person may partially or entirely lack information or may have acquired inexact information about particular options. In many cases students are not conscious of their full range of options. They lack information and knowledge about pursuing higher education or careers in science (Kao and Tienda, 1998; Madill *et al*., 2000). Often students do not know what scientists and engineers actually do on a day-to-day basis (Baker and Leary, 1995).

4.2.9 The socio-economic status (SES) of parents

The importance of the socio-economic status (SES) of parents for educational success and achievement is the most 'robust' of all educational research findings. Becker (1965), for example, suggests that parents who are themselves highly educated and knowledgeable about academic requirements are better able to help their children through school. For instance, it is more likely for children of mathematicians and scientists to also pursue careers that relate to mathematics or science. Having them as positive role models provide guidance, and hence the children are more likely to take the plunge in the same direction if they are so inclined because they have seen their parents do it. But for those children who cannot directly look up to a positive role model, the path can be more difficult.

Children from poor families are likely to have less access to learning materials such as supplementary reading materials, electronic media like television, and internet than other children will, and that they may eventually lag in college enrolment rates because family incomes cannot support tuition costs. In general, the children from families of lower-income classes may aspire less, succeed less, and achieve less. Lack of direction will inevitable result in fewer numbers of these sectors from pursuing academic studies, especially in programmes like science and science related subjects in which barriers like the ones mentioned above can easily deter prospective pupils to turn another way.

A research study has suggested that achievement in mathematics and science in secondary school, in addition to being dependent on teacher practices, "is a function of many interrelated variables, such as pupils' ability, attitudes and perceptions, socio-economic variables, parent and peer influence, and so forth" (Singh *et al*., 2002: 324).

4.3 Theoretical framework of the study

This research is within the broad tradition of constructivism traced to the work of Ausubel, Piaget and Vygotsky. This tradition currently dominates research in science education. It might not be realized immediately that constructivism could underpin a survey that involves the analysis of questions pertaining to attitudes, interests, experiences and beliefs. This could be a legitimate assertion. But, although constructivism is not in a literal sense a framework, the theoretical stance may be said to be constructivist. Constructivism may be defined as an epistemological view which sees the learner as an active participant in the teaching/learning process. The learner comes into the learning situation with prior (experience) knowledge on the subject matter. It is based on this prior knowledge that the learner interprets the new situation presented. This means that the construction of new knowledge in science is strongly influenced by prior knowledge. It is also a process where motivation and interest in the subject matter may enhance or hinder such construction to take place. The new knowledge gained may be a replacement, addition, or modification of extant knowledge. The construction of new knowledge takes place at an existing cultural context, such as geographical location, religion, social and economic class, ethnicity and language. It is within the constructivist framework to say that one should pay attention to attitudes, experiences and interests in a teaching situation. The study framework, therefore, could be seen to be organized on the principle that individuals build or construct their own meaning of new information on the basis of their existing knowledge and that what a person brings to the learning environment matters.

Each learner brings experiences that affect his or her view of the world and his or her ability to accept other views grounded in science. In this way, science education can be contextualized and linked to the life world experiences of learners. The new experiences are used by the learner to *construct* new meaning. This knowledge construction is shaped through social interactions with members of the community (Vygotsky, 1986). Thus making learning meaningful for the learner, one has to take cognizance of the social and cultural environments of the child. With recognition of the need for the child's environment in the classroom, school learning will largely be informed by the interaction between the conceptual domains of the home or community and school.

Social constructivist theorizes that learners construct meaning through interactions with others, with materials, and by observation and exploration of events (Driver *et al.*, 1994). The construction of the new meaning is most often facilitated by a *more knowledgeable other*. According to Strike and Posner (1992), constructivist-based research suggests that informal science experiences lay the critical foundations for deep conceptual understanding (cited in Jones *et al.,* 2000). As such, constructivists hold the view that learners' understanding of school science, to a large extent, is conditioned by their present commonsense experiences. This understanding, in turn is shaped by their prior encounters with various natural phenomena, even though their interpretations of such encounters may or may not be scientifically valid (Ebenezer and Connor, 1998). Hence, it is important that the curriculum should be shaped to reflect pupils' learning experiences in the affective domain (Driver *et al.*, 1994).

In the construction process, what a learner already knows or believes interacts with a new conception to which the learner has been exposed. Without both cognitive and social interaction, a new understanding will be difficult to achieve (Tobin and Tippins, 1993; Tobin, Tippins, and Gallard, 1994). A constructivist teacher plays a key role at the interface between curriculum and student to bring the two together in a way that is meaningful for the learner. Thus, teachers with a constructivist viewpoint can influence the understandings of their students, and plan mediating events that assist students in moving from a current understanding, which is not scientifically based to a more scientifically accepted understanding (Brooks and Brooks, 1999; Driver *et al*., 1994). Teaching strategies using social constructivism as a frame of reference relate to teaching in contexts that might be personally meaningful to students. These also involve negotiating understanding with students through class discussion in small as well as large groups of students (Wood *et al*., 1995, cited in Dougiamas 1998).

The study is further underpinned by the affective factors of learning. This is because the whole being of the learner is involved in construction of knowledge from the perspective of social constructivism discussed above. In other words, learning involves both the cognitive and affective domains and that the latter plays an equally important role as the former in the knowledge construction. The learner can only be motivated to engage in meaning making in science only if it is of interest and value to the learner. The nature of interest and value the learner has towards science leads to the development of attitudes towards the discipline. The learner is further motivated to engage in science learning only if the subject matter is relevant to the learner's daily activities.

5. METHODOLOGY

5.1 Introduction

It is generally accepted that the quality of any research project hinges on gathering relevant information that would be used to solve or investigate a stated problem. To achieve this, systematic methods and instruments of collecting information are adopted. The quality of these processes determines the validity and reliability of data collected.

The study is an investigation into the Ghanaian JSS pupils' attitudes, experiences, interests, priorities, expectations and images that relate to science learning. Those affective domains of Ghanaian pupils with regard to science learning were also compared with pupils of the same age cohort from different cultures and countries.

This chapter discusses the methodology that was used for the study and focuses on these areas:

- Research approach;
- Population;
- Sample, sampling techniques and participation;
- Instrumentation;
- Validity and Reliability;
- Administration of instruments;
- Coding and data cleaning;
- Interviews; and
- Method of data analysis.

5.2 Research approach

The data collection strategy for this study was a standard survey methodology within the quantitative research tradition. The study was a fixed non-experimental descriptive survey that went beyond the descriptive to the interpretive in order to provide explanations of patterns and relationships of the results obtained. Justification for the fixed non-experimental descriptive survey is that, unlike an experimental research, the variables were not manipulated (Cooper and Schindler, 2001, McMillan and Schumacher, 1997). Also according to Best (1970), descriptive research looks at beliefs, points of views, or attitudes that are held by individuals or groups in order to describe, compare, classify, analyse and interpret. Furthermore, most non-experimental fixed research projects also deal with averages and proportions (Robson, 2002).

The responses from the ROSE questionnaire were analysed through the use of SPSS version 12.0.1 for Windows (SPSS Inc., 2003) and Excel. Descriptive statistics, *t*-test, and Cronbach's reliability test were conducted on the data. Descriptive statistics provides documentation on general attitudes, experiences, interests, priorities and expectations. In this study, the characteristics of descriptive statistics were used to examine JSS pupils' perceptions towards science education. An independent sample 2-tailed *t*-test was used to explore the statistical significance of the differences in the items' mean. I used the conventional $p \leq 0.05$ level of probability as the basis for reporting whether significant differences existed between the groups of pupils' responses by gender, geographic location (urban and rural). I conducted Cronbach's reliability test only as a check for internal consistency in a composite variable.

An interview approach is used to gauge the pupils' perception of the ROSE questionnaire as such, but not to obtain a secondary source of data or to collect additional data. This, in my view, could be used to validate pupils' responses.

5.2.1 Why the choice of survey approach

A survey has several characteristics and several claimed attractions; 'typically it is used to scan a wide range of issues, populations and programmes in order to measure or describe any generalized features' as stated by Cohen, Manion and Morrison (2000: 171).

In other words, survey research is a way of collecting information from a large and dispersed group of people rather than from the very small number, which can be accommodated in a case study. A survey method is appropriate for my study because the study aims to obtain information about a specific population and also because of logistics and anonymity. The information I sought was about opinions, attitudes, and perceptions; and an accurate gauge of group interests. I used a one-shot survey design since I collected the information from a single sample drawn from the population of interest on only one occasion. The information gathered was used to describe the population in relation to the specific characteristics.

5.3 Population and sample

In a survey designed research, where information is collected from a large and dispersed group of people, the concepts of the population and the sample are very important. By population is meant the target group or the group which is of interest to the researcher. A sample is the group of individuals, who are selected from within a larger population by means of a sampling procedure. The sample represents the subjects the researcher would want to deal with because they bear the same characteristics as the target population.

5.3.1 Population

The target population consisted of all the pupils at the last year of the compulsory schooling in the Central Region of Ghana in the year 2003. It is the third year in Junior Secondary School (JSS 3 or ninth grade). Most of these schools are co-educational (male and female pupils). Although the study is geared towards all

JSS pupils in Central Region, it was not practically possible to cover entire country due to a number of constraints, such as, logistics, time, accessibility and human resources.

As mentioned, Ghana is divided into ten regions with most of Ghana's population living in rural areas. At the time of data collection (in the year 2003), Ghana had 110 political administrative districts from the ten regions, but the districts have later been increased to 138. I balanced 'ideal' requirements against practical and economical constraints; and purposively sampled the Central Region of Ghana for the study. The choice of this region is based on the assumptions that:

- the researcher is very conversant with this region;
- the ROSE instrument used was trial tested[12] with Ghanaian JSS pupils in this region;
- the Junior Secondary School science curriculum, including syllabi, schedules, exams, marking systems, and textbooks, are determined by the Ministry of Education and are identical in all Ghanaian Junior Secondary schools. Therefore, all pupils in Ghana potentially have the same opportunity to exposure of science education; and
- furthermore, the country as a whole is following one type of educational system, and all pupils take one national examination conducted by West African Examinations Council at this stage in schooling.

The compulsory schooling in Ghana is 9 years, made up of 6 years of Basic school (ages 6-12; BS1- BS6) and 3 years of junior secondary education (ages 12-15; JSS1-JSS3). The junior secondary school pupils sit for Basic Education Certificate Examination (BECE) at the end of the third year (JSS3) to terminate the compulsory schooling. This is a common national examination conducted by West African Examinations Council.

[12] In later part of July 2002, I conducted a trial test on the ROSE questionnaire. For practical and financial reasons, the trial was conducted in Winneba and its environs. Winneba is a town in one of the districts in Central Region of Ghana, and is where I am working as a lecturer in the University of Education. Sixty-five (65) pupils from two JSS3 (40 pupils from urban school and 25 pupils from rural school) were used.

Why the choice of JSS3 as target population

The choice is based on the recognition that at JSS3 most of the pupils would have reached the age of 15 years. At that age pupils are more mature and hence more likely to have done more conscious reflections on their interest, priorities and attitudes to and comprehensions of science-related issues and schooling. The JSS3 is the end of compulsory schooling in Ghana. At that stage in school, many pupils would have been expected to develop some ideas about their plans and priorities for their future. It is also the age when many educational and curricular choices are made. Lastly, the adult literacy rate which is one of the indicators for Human Development Index is based on people aged 15 years and above[13]. Therefore, it is likely at that age pupils will give more consistent responses to the questions and thereby enhance the reliability of the data.

Widening the perspective: The international comparison

The focus of this study, as mentioned earlier, is Ghanaian JSS pupils' (in particular, the Central Region of Ghana) attitudes, experiences, interests, priorities, expectations and images that relate to science learning. The JSS 3 pupils (Grade 9) participated in this study. These pupils are from both urban and rural schools in the region.

Those affective domains of Ghanaian pupils with regard to science learning were also compared with pupils of the same cohort from diverse cultures and different countries. The international comparisons could enable Ghana to see its peculiarities in relation to science education with different eye that might invite innovations when curricula are designed.

[13] Adult literacy rate has been defined by UNDP as the percentage of people aged 15 and above who can, with understanding, both read and write a short, simple statement on their everyday life.

5.3.2 Sample: Sampling techniques and participation

Considering some factors such as finance, time and accessibility, it is practically impossible to access information from a target population. It becomes appropriate therefore, to measure from a smaller group of the population. This is done in such a way that the information obtained is representative of the total population under study. This smaller group from the population represent a sample. It is not even necessary to use the whole population. One always addresses only a sample.

In selecting the sample of pupils that participated in this study, I used all the twelve (12) districts in Central Region of Ghana. In selecting a school in an urban setting I considered the following criteria: Localities of 5000 persons and above have been classified as urban since 1960 (GIR, 1994). Secondly, an urban setting in Ghana is characterised by a number of social amenities more than that of a rural location; such as electricity, hospital, pipe borne water, efficient postal system, good road layouts, police station and internet facility. I consider that all the district capitals are characteristic of urban settlements. All the schools from the urban settings for this study were therefore purposively selected from the district capitals to ensure uniformity.

The Regional Education Director was contacted, and school district approval was acquired. In each district, the District Education Office provided me with names of all the schools and with the help of the office staff I clustered them into urban and rural schools.

A total of 1027 pupils in JSS 3 from 24 schools were involved. I selected the 24 schools from the twelve districts in the Central Region of Ghana. The schools are representative of urban and rural settlements. Two schools, one each from urban and rural areas were selected from every district.

I used a stratified random sampling technique to choose the schools. A table of random numbers was used to select the schools. The national average school age of the participants is 15 years. The numbers of male and female pupils that took part in this study are 551 and 476 respectively. The numbers of urban and rural pupils are 613 and 414 respectively. This last paragraph of the present section will be discussed in more detail in chapter 6 (see sections 6.2.1 and 6.3.1)

The representative nature of sample

For practical and financial purposes as already mentioned, I conducted this study in Central Region (one out of ten regions), but the sample area is quite homogeneous in terms of school type. Although my survey samples are very small and by no means representative of the larger Ghanaian communities in which my respondents reside, the respondents' answers may prove very useful in canvassing the range of views that exist in the sample area.

I also hope through the data analysis, the study will provide interesting insights and that the findings could arguably be generalized for the entire country. However, the sample of the pupils for this study was not based on weighted average of the geographical distribution of the population (urban/rural). In other words, the urban pupil and rural pupil samples were not reflective of the percentage distribution of population by geographical location. As mentioned earlier, about seventy percent (70%) of the population are living in the rural areas, and therefore pupils from the urban setting that were selected for this study are likely to be over sampled. Nevertheless, the findings may serve as a basis for further studies.

5.4 Instrumentation

Challenges associated with measuring affective factors of learning such as interests, attitudes, beliefs, perceptions, emotions and motivation are widely known and documented both outside and within the community of science education researchers (Bennett, 2001; Gable and Wolf, 1993; Oppenheim, 1992).

The review of the literatures indicates that there does not seem to be in existence any research instrument that pertains to measure the sort of attitudinal aspects of pupils' relationship to science that the ROSE project wants to assess (see Schreiner and Sjøberg, 2004). There was the need to develop the instrument ourselves. In the following section, I will address issues of the development of the ROSE instrument.

5.4.1 Development of the instrument

The distinguishing characteristic of ROSE project is to collect and analyse information from young learners about a number of factors that have a bearing on their attitudes to science and technology and their enthusiasm to learn science and technology. The ROSE focuses on a variety of factors such as: pupils' interests in learning science and technology topics in different contexts; future hopes, priorities and aspirations; optimisms and pessimisms about environmental challenges; prior experiences and views with regard to school science; opinions about and attitudes to science and technology in society; and science and technology-related outside of school time experiences.

The ROSE instrument was developed in Norway through the inputs from international deliberations, workshops and piloting among a team of science education researchers in which I was a part. The ROSE questionnaire items were developed over one and half years to reach its final form by the Norwegian partners of the ROSE team upon the further advice of an international advisory group. The advisory group is a team comprising key international science education researchers from all continents. The questionnaire had been tried in different countries including some European and African countries. The goal was to develop an instrument that could be used in all parts of the world aimed at stimulating research cooperation and networking across cultural barriers and to promote an informed discussion on how to make science education more relevant and meaningful for learners in ways that respect gender differences and cultural diversity. Details are given by Schreiner and Sjøberg (2004).

5.4.2 Nature of ROSE instrument

The ROSE questionnaire mostly consists of closed structured questions. In total, there are 250 items under 6 headings, all on a 4-point Likert scale. This format offers the respondents fixed alternative responses. The respondents are to give their answers by choosing the alternative appropriate to their view. The Likert scale was developed by Rensis Likert in 1932. It requests the respondents to make a judgement about their level of agreement, most often, on a 5-point scale with a statement. The justification for the use of 4-point scale is given later in this section. The number assigned to each response becomes the value for that response. These numbers are arbitrary values, because it becomes difficult to know the exact 'quantity' of opinion, experience, interest and agreement (Schreiner, 2006).

There is only one question in the ROSE questionnaire which is open-ended, offering the pupils a number of lines where they can express their ideas in their own words. We (ROSE partners) believe using open-ended questions could have added some richness to our data, since pupils are given free will to express their views, but the disadvantage is that it is more difficult to administer and analyze. We rather used closed ended questions. There are a number of good reasons for that, though, there are a quite number of drawbacks. Some of the reasons are that closed questions are easy to administer, code and analyze. Collection of large amounts of data and coding is simple and relatively cheap. They are also quickly and easily answered because they do not require any extended writing (Oppenheim, 1992).

All items follow the same basic structure. A statement is presented, and the pupils are asked to give their response by ticking the appropriate box in a fixed scale. A Likert-type scale with four categories for all items was used. The general responses' range is of the form: Disagree-Agree, Not interested-Very interested, Not important-Very important and Never-Often.

The Likert-type scale was preferred to other attitudinal scales such as Thurstone scales, Guttman scales and Semantic Differential scales. Among these attitudinal scales, Likert-type scales are easy to construct. As early as 1967, Tittle and Hill commented:

> *The Likert scale is the most widely used method of scaling in the social sciences today. Perhaps this is because they are much easier to construct and because they tend to be more reliable than other scales with the same number of items (Tittle and Hill, 1967 cited in Page-Bucci, 2003:8)*

Likert scales also provide the researcher with opportunity to compute frequencies and percentages, as well as statistics such as the mean and standard deviation of scores. This, in turn, allows for more sophisticated statistical analyses such as Analyses of Variance and factor analyses to be performed on the data (Page-Bucci, 2003). In addition, Likert scales are often found to provide data with relatively high reliability (Gable and Wolf, 1993; Oppenheim, 1992).

According to Page-Bucci (2003), there still seems to be some contention within research as to whether Likert scales are a good instrument for measuring attitude (see for instance, Gal and Ginsburg, 1994). But there are also researchers who favour the use of Likert scales, for example, Robson (2002) and Neuman (2000). According to Robson, Likert scales can look interesting to respondents and people often enjoy completing a scale of this kind. Neuman, on the other hand, considers the simplicity and ease of use of the Likert scale as its real strength.

Many textbooks on research methodology provide varying recommendations for the preferred number of responses on a scale. Likert scales can have either an odd (typically 3, 5, 7, or 9) or an even number of points. Scales with an odd number possess a middle neutral point between the extremes. However, the meaning of the middle category has turned out to be complicated to interpret (Oppenheim, 1992). After careful reflections and to avoid much of these complications, The ROSE project has chosen an even number of four-point Likert-type scale rating, omitting the neutral middle point as well as the *Do not know* category.

The rationale behind this is that the respondents are in a way *forced* to take a stance. This was done in such a way that 'too many' scores on the neutral boxes category, and hence data lacking the diversity could be avoided. However, in the introduction to each question, the respondents were encouraged to refrain from ticking any of the boxes if they were not sure of the answer. In this way the pupils still have the right to remain neutral to an issue.

The scoring of the scale was done by assigning numerical values to the response categories, for example 1-4 from 'Not interested-Very interested'. In order to make the analysis easier and meaningful, the distances between each of the categories are assumed to be of equal sized interval with an arbitrary origin. This means that the analysis will involve some judgements and approximations of a quality by indicating 'less' or 'more' of that quality. I will not deliberate further on the merits and demerits of my approach to the use of the Likert scale, since it has become an on-going issue of debate about its widely used method of scaling in research in education and social sciences, particularly, in attitudinal or affective dimensions of learning. Therefore, it makes a full discussion of this point beyond the scope of this study. However, the acceptance to use the Likert scale as a method of scaling in this study is based on its widely mentioned use in the literature (see e.g. Robson, 2002; Gable and Wolf, 1993; Neuman, 2000); and it is also the most common method of scaling in international surveys like TIMSS, PISA and Eurobarometer.

Likert scale-A quasi interval scale

An interval scale has an origin which is arbitrary with equal sized intervals between categories. Unlike the interval scale, an ordinal scale, such as a Likert scale does not have equal distances between response categories (Schreiner, 2006). However, it appears it is a common practice in the attitudinal research arena which assumes equal distances between the categories in the Likert-type scale. In this study, Likert scale is used and regarded as a quasi-interval scale. This assumption has an advantage in that, the data in such an interval scale can be manipulated by addition and subtraction, and therefore be used in the most common statistical procedures (Ary *et al*., 1996 cited in Schreiner, 2006).

5.4.3 The content of ROSE instrument

A copy of the ROSE questionnaire, including the 'local' items that were added, can be found in the Appendix A.

Pupil background information

There are many extra-curricular and out-of-school factors that influence pupils' relationship to science and science education. Some of these factors are: gender, age, nationality, home language versus language of instruction, parents' education and occupation, urban/rural environment and peer culture (Schreiner and Sjøberg, 2004).

However, for the international ROSE study, there are only three items on background information that ROSE instrument requests for. These are gender, age and nationality. These are the only classification variables that were applied in the comparisons between countries.

Though part of the thesis compares Ghanaian pupils with pupils from other countries, the main focus is on Ghanaian data. I have also added some other background variables such as: school type (urban/rural), parents' education and occupation, place of birth and district to the ROSE instrument. These variables were meant for contrasting groups in the national data. The issue of the background information of pupils will be addressed later in this chapter.

The ROSE questionnaire has a large number of items, and in the following section, I will discuss the main themes or questions which go from ''A'' to ''H'' in the questionnaire. I will take them by themes.

''What I want to learn about'' (ACE)

The group of 108 items under this question are possible topics to learn about, each with a 4-point Likert scale from 'Not interested' to 'Very interested'. To avoid fatigue on the part of the pupils, the items are grouped into three questions: question A, C and E, but they are referred to as question ACE in this study.

An underlying hypothesis in this question is that many young people, although they do not plan to be scientists or have a scientific career, find various aspect of science interesting. The idea about these questions is to get empirical evidence on what sort of issues pupils are interested in learning about, and to explore how these vary between groups and to search for patterns in the answers. This question may provide insight into how different topics may appeal or not to different groups of learners. This information can give an insight into how science curricula may be constructed to meet the perceived needs or interests of different groups of pupils.

However, we must be aware of the limitations of the ACE questions. The questions only address the issue of *what* to teach (the content) and not *how* to teach (the teaching method or pedagogy). There is great variety of teaching methods and learning activities. These different methods serve various educational purposes and have different capacities of motivating pupils and attracting their interests (Schreiner and Sjøberg, 2004).

Furthermore, all teachers know that teaching method or pedagogy does indeed make a difference (Osborne and Collins, 2001), but it can not be interpreted in this study whether a teacher actually will succeed or fail with teaching 'interesting' topics. It is also a concern that teaching 'interesting' topics does not necessary guarantee a successful or meaningful teaching, but it makes sense to teach 'interesting' topics rather than topics deemed by pupils to be boring.

The value of these questions is to identify subject matter that appeals to pupils; however, there are a number of pupils-group profiles that may differ on different matters that need to be focused when addressing issues in science education. An issue, such as topics that interest or appeal to pupils: Can we think of universal pattern? How do culture, gender and geographical background come into play?

“My future job” (B)

Views of the future are inevitably influenced both by the personal background of the individual and by contemporary societal events and developments (Schreiner and Sjøberg, 2004). By knowing the images and visions young people hold of the future, one can better understand their motivation, choice and actions.

Educational choices for example, in modern societies are not only based on income and possibilities in the labour market, but also on identity development. But the circumstances and obstacles in a developing country like Ghana are very different when it comes to educational choices. It becomes an impossible dream for young people in many developing countries to have a chance to choose the job they want. In other words it is very difficult to come by a preferred job. Choices can be highly affected by changes in society that affect the structure of economic opportunities. Whatever the structure of economic opportunity in any society may be, always people expect their job to be well paid.

It is also likely that an individual’s choices are limited by the knowledge one possesses about the existing possible options. An individual may partially or entirely lack information or may have acquired inaccurate information about particular options. In many cases pupils are not aware of their full range of options. They lack information and knowledge about pursuing higher education or careers in science (Kao and Tienda, 1998).

This question therefore provides an opportunity to obtain information about the future priorities and motivations of the pupils. The information provided may allow for interesting comparisons across cultures and between boys and girls, as well as urban and rural. The question presents 26 statements on some issues for a potential future occupation or job. Each statement is followed with a 4-point Likert scale from ‘Not important’ to ‘Very important’.

‘‘Me and the environmental challenges’’ (D)

The import of this question is to tap different aspects of pupils’ relationship to the environmental challenges. Many studies in science education have focussed on pupils’ alternative conceptions of science content (Duit 2004), but less about their attitudes, priorities and decision-making regarding science learning and environmental issues. As science educators we need to develop knowledge and awareness of what challenges we are facing in our effort to make pupils equipped to meet the environmental challenges (Schreiner and Sjøberg, 2004).

The data analysis and the discussion of the results will offer us as science educators a deep knowledge on how youth would want to associate with some environmental matters and possible implications for science curriculum.

This question has 18 items on some environmental issues followed with 4-point Likert scales which go from ‘Disagree’ to Agree’

‘‘My science classes’’ (F)

This question provides information about different aspects of the pupils' perception of their science classes, including their motivation for science at school, their self-confidence in their own abilities in science at school, what they get out of science at school, and their perceptions of the necessity of science education. This is because some aspects like self-confidence, attitudes, interests, beliefs and motivation are key factors associated with learning a subject. The responses provide an opportunity to describe what pupils in Ghana and in different countries actually think they have learned from their science classes.

The question has 16 statements, each with a 4-point Likert scale from ‘Disagree’ to ‘Agree’

"My opinions about science and technology" (G)

This question probes into pupils' perception about the role and function of science and technology in society, and their expectations of science and technology. The question consists of 16 items on issues about science and technology, each with a 4-point Likert scale from 'Disagree' to 'Agree'

"My out-of-school experiences" (H)

This question provides information about pupils' out-of-school experiences or activities that have a bearing on their interests in science and technology, and school science. These may provide important experiences for the learning of science at school. This is because a meaningful teaching is built on the learners' experiences. This question can provide such insights. Also, responses to this question will give teachers, curriculum makers and textbook writers a description of what kind of science and technology-related experiences children bring to school, and how these vary between girls and boys, urban and rural, and between diverse cultures.

The question has 61 statements on activities or experiences, each with a 4-point Likert scale which goes from 'Never' to 'Often'

"Myself as a scientist" (I)

This is the only open-ended question, where the pupils are invited to express opinions with their own words. The question has two parts. The first asks about what they would like to research on and the other asks for reasons for the particular choice. The first part is categorized into subject matter area (e.g. medicine, chemistry, physics, biology computer technology and environment). The second part is classified in terms of personal motivation and values (e.g. helping others, personal interest or curiosity, seeking money and success).

This free-text question allows the pupils to express themselves freely and provide some details which may be a rich source of information. The question allows respondents to express any additional insight or opinions.

"How many books are there in your home?" (J)

This is the last question in the questionnaire and has seven response categories: None, 1-10 books, 11-50 books, 51-100 books, 101-250 books, 251-500 books and More than 500 books. This is mainly to serve as a proxy for the socio-economic status (SES) of pupils' parents. The number of books in the home has turned out to be a good proxy for the socio-economic status (SES) of pupils' parents (Lie, Kjærnsli and Brekke, 1997). However, the use of this type of proxy for SES of pupils' parents becomes complicated in developing countries. Books at home are not often arranged on bookshelves. They are either arranged on a writing table, kept in boxes or cupboards. It becomes difficult on the part of pupils to make an accurate judgement about number of books at home.

Previous studies have shown that parents of higher SES are more involved in the education of their children than parents with low SES, and thereby stimulating more positive attitudes and motivation to learn, better homework conditions, higher achievement (Ho Sui-Chu and Williams, 1996; Turmo, 2003).

The prime concern of ROSE project is not about pupils' achievement, but because of the contemporary research interest in SES, the question on number of books at home has been included to address this issue.

As already mentioned, I added some demographic questions to the ROSE questionnaire for the national analysis.

Pupils' background characteristics

Parents are the first models and most important educators for children. The level of education as well as the type of occupation of parents could influence pupils' relationship to education in general (Anamuah-Mensah, Mereku and Asabere-

Ameyaw, 2004). Other demographic factors which may also influence pupils' relationship to science and science education have also been included in the national data as 'local' items. These items are questions regarding the geographical position of sample schools, socio-economic background and linguistic identity of the pupils in the sample area. The demographic questions included are: location of school (rural/urban), district, place of birth[14] (a means of identifying linguistic identity) and parent's education and occupation (to find out socio-economic backgrounds).

5.5 Validity and Reliability

The quality of a research instrument or a scientific measurement is determined by both its validity and reliability (Aikenhead, 2005). Validity seeks to determine whether the instrument actually measures what is intended to be measured and reliability, on the other hand, refers to the consistency of data when multiple measurements are gathered (Gott, Duggan and Roberts, 2003).

5.5.1 Validity

The ROSE instrument was designed for exploring the variations in affective domains of science educational objectives, such as variations in interests, experiences, priorities, perceptions and attitudes. However, there are no direct means for measuring affective dimensions as it exists in the physical sciences for the measurement of, for example, length and weight.

[14] The background question requesting for information about place of birth was a subtle way of identifying the linguistic identity of pupils in the sampled area. This was done to avoid the feeling of any tribal sentiment.
The majority of learners in Ghana are taught science in English language other than their mother tongue/first language and this seems to contribute in part to the learners' poor conceptual understanding in science. A young Ghanaian science learner will have to move between two languages in order to learn and make meanings in science. The question is how can we equip these learners with the necessary language skills in order to improve on their interest and performance in science and technology learning?
From a teaching point of view, one rich area of investigation in Ghana has been that of exploring how teachers work with mother tongue learners and migrant learners in a typical science classroom. For many reasons, such as socio-economic, every region in Ghana is often a home to many different migrant groups. How to build linguistic bridges between school science and pupils has become an important issue for science educators in Ghana.

The instrument has indirect means that involves a number of items that are selected to serve as indicators of some more complex constructs, such as the environment, health and modern technology.

In considering validity, one is concerned about how useful or meaningful the instrument is for measuring the intended dimensions. In other words, will the instrument measure actually what it is supposed to measure and that the data collected represent the respondent's opinions accurately?

The ROSE questionnaire has been developed through a thorough process involving many different actors. This process has also served as some kind of triangulation or validation of the instrument. The process included the following:

- pupils, teachers and researchers from many countries gave their ideas for items in the questionnaire;
- pupils and researchers from many countries promoted the gradual improvement of the items by review of face validity; and
- pupils gave their responses in interviews, discussion groups and in pilot studies.

Another step worth mentioning is the joint discussion on the questionnaire items between the Norwegian ROSE partners and the supervisors in the GRASSMATE programme (in Bergen in Norway, 2000). Input from the GRASSMATE meeting, which centred on cultural balance and different values and worldviews in different cultures were taking into account during the second revision of the questionnaire items.

All these processes, I believe, have ensured sufficient validity in most of the dimensions that the questionnaire intends to assess. The study can thereby provide evidence for valid inferences.

5.5.2 Reliability

There may be some weaknesses in the data through the data collection procedure. These are likely to be unnoticed; however, they raise questions about the reliability of the data.

Reliability is about the consistency in a research results. If the survey is given again, will it yield the same or similar results? Reliability of the data can be assessed if the items are examined to show internal consistency. A measure for this internal consistency (or reliability) may be gauged by the use of Cronbach's alpha. However, repeated measurements of the same quantity with the same instrument seldom give exactly the same value. This is partly because of the error inherent in the scientific instruments itself during scientific measurements (Aikenhead, 2005) or partly because of the transient nature overtime of the quantity that is measured using a survey instrument, for example, evaluating attitude, interest, belief and view. Social interaction and influence, for instance, may be key factors of changes in belief or attitude. According to Crawley and Koballa Jr (1994), people make evaluative judgements about a wide variety of targets and rely on these judgements in deciding among several possible courses of action in the future. The theory of reasoned action proposed by Fishbein and Ajzen (1975) rests on the assumptions that humans are rational and have control over their behaviour. They also seek out, utilize and process all available information about pending decision before taking action. For these reasons, affective dimensions of learning are likely to change with the passage of time. Hence attitude, for example, continues to be a subject of research in areas of social psychology and science education. I will come back to the issue of reliability in more detail at sections 5.10 and 7.4.

5.6 Piloting and pre-testing

Questionnaire pilot-testing or pre-testing identifies questions that respondents have difficulty understanding or interpret differently than the researcher intended.

Therefore, once a survey is developed, it is either pilot-tested or pre-tested or field tested with a small sample of potential respondents prior to the full survey. This is done to ensure that instructions, questions and scale items are clear. Improving on a research instrument through piloting and pre-testing is likely to improve on the quality of data, the results and interpretations.

5.6.1 Piloting

The draft ROSE questionnaire was translated into Norwegian and piloted in five Norwegian school classes. The purpose of the pilot test was to:

- gain experiences on procedural matters and practicalities on organizing the survey;
- receive reactions from pupils and teachers to the questions;
- understand what meaning and understanding pupils put in the various items; and
- do some analysis of the data and evaluate some statistical features in the material.

Some 130 pupils from the tenth grade answered the questionnaire. They were requested to indicate the items they did not understand and those they felt comfortable with. The Norwegian team further arranged a discussion in a group of eight pupils about their attitudes to and understandings of the questions. Through the discussion the team had very important feedback both from the pupils and the teachers. The data from the pilot testing were coded in SPSS and statistical analysis was carried out. The results from the analysis were discussed with scholars in psychometrics at the Faculty of Education in the University of Oslo. A similar pilot-test was done in Japan and Uganda.

It is important to keep in mind that for practical and financial purposes, the pilot testing had to be conducted in Norway and in other countries such as Japan and Uganda. Although from the cross-cultural point of view of the ROSE project, it is not fair to carry out such trails in few countries. But it is believed that the feedback provided by these countries through the pilot test, had given an important input to the revision of the questionnaire.

5.6.2 Pre-testing in Ghana

The ROSE questionnaire was pre-tested with 65 JSS pupils from two schools, one urban and one rural in one district in the Central Region of Ghana. The purpose of the pre-test was firstly, to detect difficult sentences, concept and wording and also to gauge their reading ability. The second reason was to determine the length of time they may use for questionnaire response. My intention was not to alter the construct or content of the questionnaire, but to look for possible challenges that are likely to surface during the administration of the instrument or to identify anything that might go wrong on the day of the survey. The survey instrument was not modified because, as already mentioned, this study is based on the international ROSE project, which makes it mandatory for all participating countries (including Ghana) to apply a similar instrument both in content and the order in which the items have been presented. The reason behind this was to make comparisons across countries or cultures easier and meaningful.

I requested them to tick the items they felt uncomfortable with as they went through the questionnaire. I did a random selection of five answered questionnaire from each school, identified the respondents and had discussion with them about the items indicated.

From our discussions I found that:

- some of the words/statements/items were not familiar due to different cultures and traditions;
- the original ROSE questionnaire provided rating scales with only the endpoints labelled with words and the points in between not labelled. As such, many pupils could not figure out the titles for the middle scale;
- some of the pupils had difficulty with reading and took longer time to complete the questionnaire; and

- there was the need to explain some of the items in the local language. This was helpful, though the explanation could carry different connotations.

However, Waldrip and Taylor (1999) have confirmed that some important information is likely to be lost in translations (or explanations).

According to Krosnick (1999), questionnaires have routinely offered rating scales with only the endpoints labelled with words, and the points in between either represented graphically or labelled with numbers and not words. However, reliability and validity can be significantly improved if all points on the scale are labelled with words, because they clarify the meanings of the scale points (Krosnick and Berent, 1993, cited in Krosnick 1999). In order to improve on the quality of response, I inserted labels which I deem appropriate for the middle scale.

Some of the items that the majority of pupils showed difficulty in comprehending are, generally, from 'A and C' questions. These questions ask about science topics they wish to learn about. The difficult words indicated by the pupils are in boldface. The items are: **Cloning** of animals; **black holes**, **supernovas** and other spectacular objects in outer space; how **meteors**, **comets** or **asteroid** may cause disasters on earth; eating disorders like **anorexia** or **bulimia**; plastic surgery and **cosmetic** surgery and how radiation from **solarium** and the sun might affect the skin. All these items are from 'A' questions.

Those items from 'C' questions are: Astrology and **horoscope**, and whether the planets can influence human beings; alternatives therapies (**acupuncture**, **homeopathy**, yoga and healing) and how effective they are; **thought transference**, mind-reading, **sixth sense** and intuition. 'Tried to find the **star constellations** in the sky' is the only item in 'H' questions for which some of the respondents could not understand.

I also cited English language for those who are not especially articulate, as a contributing factor to the lack of comprehension of some of the items. Most of the pupils from the school in the rural setting had limited English comprehension skills compared to those from the urban setting. For example, it has been cited in a World Bank report on Ghana that, the problem with the language of instruction, which is one of some major causes of poor teaching and learning outcomes, put poor rural children with little linguistic ability at a disadvantage (World Bank, 1996). Such group of pupils might have difficulty understanding some of the items and are likely to take longer time to complete the questionnaire.

5.7 Administration of instrument

The survey was conducted from early February to late April in the year 2003; this is the normal period for which all schools are back from the Christmas break.

Once the schools were selected, letters of notification of and participation in the study were given to me by various District Directors of Education to be sent to those schools. I went to the schools, in order to introduce myself to the Heads of school and to brief them on the nature of the study.

I did not send the letters by mail, because some of the selected rural schools are in very remote areas with unreliable postal services. Since I conveyed to the Heads of school the aim of the study and its importance and assured them of confidentiality, all the selected schools were encouraged to participate in the study. The survey was conducted by me in person at each school, but assisted by each class teacher. Every effort put in by any teacher was rewarded with a token fee. In order to have a common stand on explanations and meanings of some of items which may be difficult to pupils, I went through the items with the Head of the school and class teacher before meeting with the pupils.

At each school, the Head of the school briefed the terminal class about the exercise and I went in to administer the questionnaires. One teacher or two in some cases assisted in administering the questionnaire either by reading through the items or explaining some of the unfamiliar words to the respondents. I did that in order to keep the answering of the questions within a reasonable length of time. And also the possibility of lack of comprehension and reading ability amongst pupils might not hinder the exercise. I collected the answered questionnaires the same day that questionnaires were administered.

5.7.1 Major challenge during the administration of the instrument

Some of the schools in the rural settings are in very remote areas in Ghana and transportation systems to these villages are very erratic. There are a few motor vehicles that ply the roads and service the villages. One is likely to miss a transport to such a village, and in that case, the only alternative is to walk. I met a number of such situations when collecting the data. I got to some of the schools when they had just closed for the day since I walked. Though, some Heads of school were able to assemble the pupils for the exercise to begin, others could not and I had to put up with them for the night since hotels and guest houses are not available in those areas. The questionnaire had to be answered the next day. This therefore, affected the subsequent visits to other schools.

5.7.2 Factors that might impact on the quality of the data

As mentioned earlier, I got to some of the schools in the rural areas late when the schools had closed for the day due to some practical constraints, such as lack of means of transport to some of the rural areas. Some Heads of school managed to detain the pupils in the schools to attend to the questionnaire.

In such circumstances, some pupils might not be in their right state of mind. They may not give serious attention to the questions or may regard the exercise as very tedious and time consuming. Some of them are likely therefore, to complete the questionnaire in an unthinking or hurried manner.

The period within which I collected the data was when the pupils had just completed with their trial examinations leading to the national examination which is taken by all JSS3 pupils. The national examination is taken to terminate their compulsory schooling. The trial exams is a regional based one which is conducted by each of the Regional Education Office, with the Districts Education Office having the overall supervision responsibility. The examination questions are brought from the District Office and are supervised by both staff from District Office and teachers in a particular school.

Though, they had just completed the trial exams, some of the pupils took fright at my presence in their classrooms, when holding a lot of printed material (the questionnaire). Despite our (including the Head of school and the class teacher) persistent assurance that it was not an examination and that any option of theirs to an item is a right answer, some of pupils were physically shaken and nervous as they answered the questionnaire. This might affect their choice. I chose that period to administer the questionnaire because all JSS3 pupils are likely to report at school regularly due to their preparations towards the national examination and to ensure a probable large sample size.

These factors, including the explanations given to some of the items in the local language, are likely to influence the quality of the data; however, an interview was used to assess these types of factors in order to guarantee the quality of the data. I will come back to details concerning the interviews in chapter 13.

5.7.3 Limitations of the study

According to Best and Kahn (1989), limitations are conditions beyond the control of the researcher that will place restriction on the conclusion of the study and its application.

Limiting the survey to one region out of ten regions in Ghana might not reveal a general picture about the views of the pupils in relationship with science learning at JSS level. The survey was also confined to a structured standard questionnaire that considers cultures in all continents thus limiting the views of the respondents.

In addition, quantitative research allows comparisons to be made among groups of respondents based on mean values. The grouping of respondents can be done, for example, along gender, age, school type, and urban/rural place of living. According to Schreiner and Sjøberg (2006), all quantitative research based on groups of respondents entails a loss of information at the levels of the individual but it facilitates characteristics of the *typical* at the expense of the *particular*. In this study, the focus is on the *typical* and groupings have been done based on gender and urban/rural place of living. The characteristics of these groups are presented by mean scores of all respondents in a given group instead of individual scores. The loss of information at the levels of the individual is therefore compromised in the study.

As mentioned earlier in section 5.3.2, concerning a generalization of the findings, I emphasize further that since the purpose of this research was to seek insight into the interests, experiences, attitudes, views and beliefs of pupils. As such, the objective is not necessary to provide findings that can be generalized to larger populations, but rather, to explore the range of affective dimensions of science learning that are generally held within the populace. Hence generalizations of findings must be done with caution.

5.7.4 Delimitations of the study

The study was limited to the JSS3 level pupils at some selected schools in the Central Region in Ghana. At this moment, apart from the affective factors of learning regarding pupils' relationships with science and science learning, the study did not take into consideration any other factors that influence science learning, such as, parent, peer, societal and school influences; and teacher-pupil interactions.

5.8 Coding and data cleaning

The SPSS (Statistical Programme for the Social Sciences) as a computer programme for analysis was used for the coding. I did data entry directly into the prepared SPSS empty data files that were sent to me by e-mail from ROSE project partners in Norway. I entered the data myself in accordance with the guidelines in the 'ROSE Handbook', which was also provided. I did self-entry of data in order to have confidence in the data entry procedure.

As mentioned earlier, the original ROSE questionnaire was given titles for the extreme scale. I had to insert titles for the middle scale to avoid confusion which was demonstrated by pupils during the pre-testing. The entry was therefore done on a scale from 1 to 4, according to the place of the tick. The actual position of the respondents' tick was the value entered (a tick in the first box was coded and entered as '1', a tick in the second box was coded as '2' and finally to the forth box). This made it straightforward.

I provided number codes for the national items and fitted into the original coded SPSS empty data file in a coordinated fashion. For example, '9' which was used for missing data, was not used as a code for any of the national items but used purposely as a code for any missing item. The number codes for the 12 districts go from 1 to 13, excluding 9. The different educational levels and types of occupation of parents were all given number codes.

In all the questionnaires, any respondent who did not satisfactorily fill the categories, including symmetric patterns, empty spaces and pages and choice of two or more categories for an item, those variables were coded with '9' and regarded as missing data. I used this coding procedure for the national items, except items like "rural/urban" or "district" which is a general characteristic of each respondent in a particular school.

I did data cleaning of the file by looking for empty cells, cells coded with two digits, and cells coded with numbers different from the allowed numbers for the question. Since I provided each questionnaire responded with an identification number, it facilitated identifying any questionnaire with coding error. It was time consuming to enter data on 250 items and 8 ‘local’ items from each of the 1027 participants in the study. This took one month to complete working consistently.

5.9 Interviews

An interview is a self-report method. It occurs when a participant is asked questions that have been designed to elicit particular types of information. The questions may be structured, semi-structured or unstructured.

It is virtually impossible to determine whether or not the respondent is giving serious attention to the questions in the self-completion questionnaire, or regarding the exercise as a tedious chore, and might be completed in a cursory manner. An interview may permit the assessment of this type of factor, and give the possibility of differentiating respondents on this basis (Robson, 2002).

In this case, the interview is used to guarantee the quality of data. Furthermore, where a quantitative study has been carried out, qualitative data are required to validate particular measures or to clarify and illustrate the meaning of the findings, and to see whether their experiences concur with the ratings on the measure (King, 1994). This was the prime focus of my interview.

It could not be possible to interview all respondents hence individual interviews were conducted for eight (8) pupils from those who opted for the interview. The pupils were selected from four (4) schools (two schools each from urban and rural areas respectively). For each school a girl and a boy were chosen. The aim for the interview was to:

- give pupils the opportunity for free expression to perceptions that are too subtle to be detected by more conventional methods;
- determine whether the pupils' expressed views were consistent with their questionnaire responses; and

- assist in interpreting and explaining the findings using the interview data.

I carried out an initial descriptive statistics on the dataset to determine frequency distribution of pupils' response. This exposed unexpected patterns, which provided an important breakthrough suggesting a basis for the interview questions. The criteria used to select the questions for the interview included the following:

- 'missing' category is greater than or even with the frequency of selected options;
- frequency distributions of the different options selected by the pupils are almost similar; and
- a high proportion (frequency) of the pupils indicate the negative options of the items.

The reasons for each of the criteria were to investigate the:

- failure of pupil to indicate an option or selecting more than one option;
- even distribution of the pupils' responses even though they are of the same cohort; and
- pupils not interested in or disagree to the item(s), even though the item(s) may be of importance to the pupil in his/her daily activities.

I used semi-structured interview approach. This was because, firstly, I predetermined the questions around the six main themes in the ROSE questionnaire. Some of the questions were modified based upon my perception of what seems most appropriate and also to suit the peculiarities of the interviewee. Secondly, semi-structured interview approach is one of the most widely used methods of data collection in qualitative research (Kvale, 1996).

I arranged with the school's administration to interview the pupils in the office of the Head of the school. Each pupil was interviewed separately and typically lasted approximately 20-30 minutes. After a period of making the pupils as comfortable as possible by asking them about their school, what they have heard about the study, and by letting them listen to their voice on the tape recorder, the interview began. All interviews were recorded on audio-tapes after each subject had granted permission. The recorded interviews were transcribed and used to validate the findings.

5.10 Data Analysis

I analysed the responses to the ROSE questionnaire through the use of SPSS and Excel. An independent sample 2-tailed t-test was conducted to explore the statistical significance of the differences in the items' mean for two groups. The conventional $p \leq 0.05$ level of probability was used as the basis for reporting the differences in means between boys' and girls' scores; and between urban and rural pupils' scores. The statistically significant differences between Ghanaian pupils and pupils' within diverse cultures were not calculated, but were reported using graphical representations.

The ROSE questionnaire is lengthy (250 items). The questionnaire statements were provided to reflect diverse cultures and to befit an international comparative study. To overcome the amount of data it presents, some of the items were purposively grouped into cluster of items. A cluster of items then constituted a composite variable which is given an appropriate name. The name represents the common factor of the items making up the variable. This approach lifts discussion up from the items to a more general level (Schreiner and Sjøberg, 2004). However, to identify some interesting stereotypical differences between group profiles, single item analysis was done for some sections of the questionnaire.

In this purposive grouping of items, I 'handpicked' the items to be included in the cluster on the basis of *content* (subject matter areas) and *context*. This implies that the clusters of items did not emerge from factor analyses. However, I subjected the clusters to reliability analysis with Cronbach's alpha (α) to measure the internal consistency within a group of items. Internal consistency is the degree to which the items that make up a scale are all measuring the same underlying attribute (that is, the extent to which the items 'hang together').

Since the items forming one composite variable may not be the best possible selection of indicators or items from the universe of indicators relevant to the name of the variable, the composite variable are not to be considered as a construct, but rather an index representing the clustered items.

A Cronbach's alpha (α) is an indication of the average correlation among all of the items that make up the cluster. Nunnally (1978) recommends a minimum Cronbach's alpha level of 0.7; however, it depends on the number of items in the cluster. It is possible that an item may have different connotations in different cultures and in that case the items may cluster differently in the different countries. Hence, the international comparisons in this study were done on a single item basis. For this reason, I used some of the outputs or results from the international comparisons which have already been generated by the ROSE project partners in Norway.

5.10.1 Approaches to the analysis of various questions (themes)

The ROSE instrument has eight subsets of items that are measured on Likert scale. Each subset has a theme and also represented by a letter from 'A' to 'H' for the eighth subset. The subsets 'A, C and E' have the same theme.

"What I want to learn about" (ACE)

The mean scores for each variable were calculated, for boys and girls separately as well as urban and rural school pupils. The most popular and the least popular topics for each of these groups were compared.

In order to understand the situation more completely I put some of those science topics into smaller components of science subject areas as they appear in the JSS general science course. The items were clustered into the traditional science curriculum content areas (physics, chemistry, biology, agricultural science and health science). These are, however, not taught as separate subject areas, but as general science in JSS and taught by one teacher. For current trends and issues in science education, environmental protection and technology were included as context and content areas respectively for cluster of items. This approach could give an insight into the stereotypical differences between girls' and boys' interests towards science subject areas.

The relationships between the responses to 'ACE' questions and the questions on 'My future job' (B), 'My science classes' (F), 'My opinions about science and technology' (G) and 'My out-of-school experiences' (H) were found.

"My future job" (B)

I analysed the questions on future careers on a single item basis for all groups of pupils. Relationships in responses in (B) were sought between 'My science classes' (F) and 'My opinions about science and technology' (G).

"Me and the environmental challenges" (D)

The mean scores for each variable were calculated for all groups. This may give clearer picture of pupils' engagement with environmental protection and challenge issues. The views of pupil about the environment were related to future career areas in (B).

"My science classes" (F)

Attitudes formation is key factor in learning as a whole. Pupils' attitudes towards school science are very important aspect to school science learning. It might therefore be better analysed as item by item so as to compare gender, as well as urban and rural school pupils' differences in attitudes towards science education.

"My opinions about science and technology" (G)

I reported single-items scores for each of the items for all groups of pupils. Agreement and disagreement profiles could be seen clearly with the single-items analysis.

“My out-of-school experiences” (H)

The information from this question provides an insight into the activities or experiences of pupils out of school. Those which have bearing on their interests in science and technology may provide important experiences for the learning of science at school. The responses were analysed item by item. This could provide a picture of most frequent and least frequent activities performed out of school and how they differ for boys and girls as well as urban and rural pupils.

Socio-economic status of pupils’ parents

The number of books at home which is in question (J) was analysed vis-à-vis the local items on the parents’ educational and occupational backgrounds of pupils and these were linked with some of the items in the other subsets of the questionnaire.

“Myself as a scientist” (I)

As already mentioned in section 5.4.3, it is an open-ended question asking the pupils to express their opinions with their own words about themselves as scientists. The item (I) presumes the child’s imagination as a scientist. Though, the dataset from their responses on this item forms part of the larger Ghanaian data I did not analyse the results of this subset, ‘Myself as a scientist’. It was not appropriate to do analysis in this study considering the fact that the subset does not address the research questions (see section 1.3.3).

5.11 Ethical considerations

Since human beings provided information, which formed the data for this study, it was necessary for me to inform them well ahead of time about the more general aim of the ROSE research project, and to request for consent of the pupils to be involved in the study. The same information was provided to teachers, heads of school and educational authorities. However, my specific objective of basing a PhD thesis on the data from this research was withheld from the information given to the people that were concerned with the study. I took this action with the mind that pupils are more likely to provide views on questionnaire items that could be the true reflections of themselves and to avoid the possibility of participants pleasing me. To other educational facilitators, I wanted to avoid possible frustrations from them. Nevertheless, the general aim of the study, which I provided regarding the research outcome was hoped to provide empirical evidence that could inform decisions for a possible improvement on science teaching and learning focusing on affective factors of learning.

For these reasons, the following ethical issues for research were ensured:

- the schools and the pupils participated voluntarily through the permission of the educational authorities;
- through a letter to the educational authorities, heads of school and the pupils in the survey area were well informed and clearly understood the objective for this research; and
- the research instrument, which was scrutinized by educational authorities was designed in a way that will not invade the personalities of the participants in the study; or criticize the learning methods employed by teachers and educational facilities available in the schools taking part in the study.

Confidentiality was ensured during transcriptions of the interviews, analysis and reporting. The participants in the study were assured of anonymity, and their names were not disclosed in any way. The information provided will not incriminate the respondents in any way either.

In this chapter, the issues of research methodology have been dealt with in more detail, focusing on population and sample, instrumentation including validity and reliability issues. The administration of instrument, method of data analysis and ethical considerations has been discussed.

The next chapter provides information about the sample characteristics and other relevant background information of respondents. As mentioned earlier, some of the concerns in Ghana's educational reforms are how to make education more accessible to every Ghanaian child; how to sustain interest in education and how to foster better attitudes towards education through a curriculum that is fair to both genders; and social classes or geographical background. In order to shed light on the relative importance of the geographical and the gender aspects of the discussion of the science curriculum, I have analysed the data from these two perspectives with regard to Ghana.

6. THE SAMPLE DISTRIBUTION AND SOCIO-ECONOMIC STATUS

6.1 Introduction

In studies involving human subjects, it is useful to collect information on the number of peoples or cases, the number and percentage of males and females or urban/rural people, the range and mean of ages, education, and any other relevant background information. These are covered in detail in this chapter.

Also, it is a known fact that one of the goals in the design of sample survey is to obtain a sample that is representative of the population so that precise inference can be made. The selection of Central Region in Ghana for this study is based on convenience rather than on probability, and also for cost and time advantages. However, one should be extremely careful in making inferences from a non-probability sample; whether or not the sample is representative is dependent on my own judgment and not on sound statistical principles.

In this study, I made an assessment of the socio-economic status of parents of pupils in the sample in the Central Region. Several research studies continue to suggest that socio-economic status, among other variables, could impact on attitudes towards and achievements in education. For example, research has shown that parents of higher SES are more involved in the education of their children than parents with low SES (Ho Sui-Chu and Williams, 1996). Parents of higher SES are likely to stimulate more positive attitudes and motivation to learn. They are able to create better homework conditions, which may result in higher achievement (Turmo, 2003).

This chapter presents the results and discussion of the sample characteristics and socio-economic status of parents in the sample. Some information gathered regarding occupation and educational levels of parents of pupils in the sample has been used to interpret some of the findings emerging in this study.

6.2 Results

Figure 6-1 gives the sample characteristics of the pupils by age, and figure 6-2 is a graph of sample characteristics by gender and geographical location (urban/rural). The results of socio-economic status of parents are presented as in the illustrations (see figures 6-3, 6-4 and 6-5).

6.2.1 Sample characteristics

The questionnaire was administered to 1027 JSS3 pupils from 24 schools. Twelve schools each in rural and urban communities were involved. The third year junior secondary pupils in this study were between 10 and 23 years (see figure 6-1), with mean age of 15.20 years and standard deviation of 1.43. The mean age of 15.20 compares favourably with the ROSE project's age cohort of 15 and national mean age of 15. The proportion of ages between 10-13, 14-16 and 17-23 years were 90 (8.8%), 782 (76.1%) and 155 (15.1%) respectively.

In the total sample, 551 (53.7%) were boys and 476 (46.3%) were girls. By location, the proportion of pupils from schools in urban areas was higher than for the rural areas, 613 (59.7%) as compared to 414 (40.3%). For urban schools, they were 310 (30.2%) and 303 (29.5%) for boys and girls respectively. The distribution of boys and girls in rural schools pupils were 241 (23.5%) and 173 (16.8%) respectively (see figure 6-2).

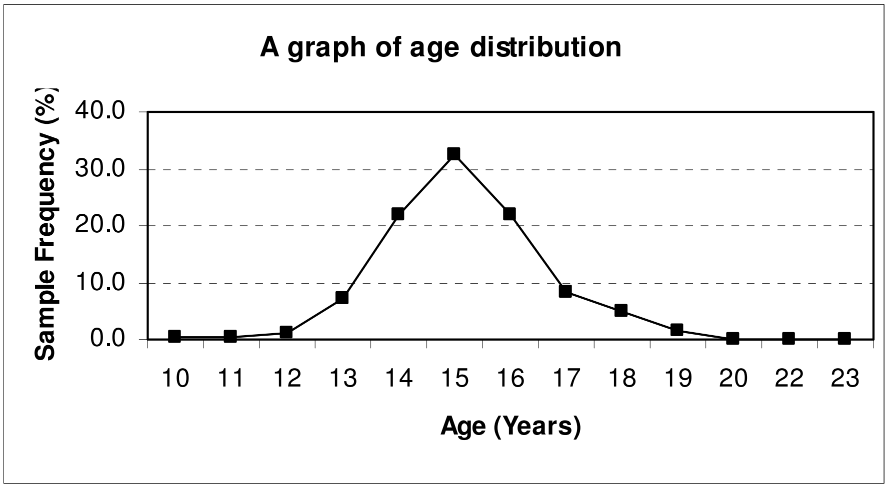

Figure 6-1. Sample characteristics by age.

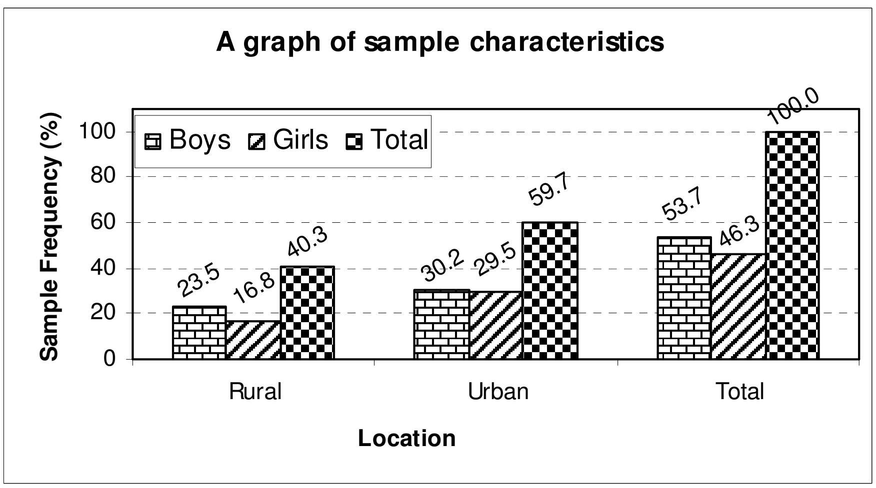

Figure 6-2. Sample characteristics by gender and geographical location.

6.2.2 The socio-economic status (SES) of parents

The questionnaire has local items requesting pupils to provide occupation and educational levels of parents. There is also an item asking for number of books (excluding magazines) in the home. This was used as a proxy measurement for parental education and household/family wealth (see for example, Lie, Kjærnsli and Brekke, 1997). The results are presented as illustrations (see figures 6-3, 6-4 and 6-5). The data are given for fathers and mothers (except figure 6-5). In figure

6-3, most parents had their educational level up to middle or Junior Secondary School, 404 (39.3%) and 327 (31.8%) for mothers and fathers respectively.

In figure 6-4, twenty-three (23) different types of parental occupation were identified in the area of survey from pupils' responses. Most mothers were in trading (buying and selling), farming, teaching, health service and vocational occupations. The most common occupation among mothers was trading 523 (50.9%), followed in descending order by farming 256 (24.9%), teaching 59 (5.9%), vocation 31 (3.0%), and health services 26 (2.5%).

Less than two percent (2.0%) of fathers were engaged in each of the high income earning occupations, such as medical doctors, engineers, administrators and directors of education among others. Most fathers were into subsistence farming and fishing 446 (43.4%).

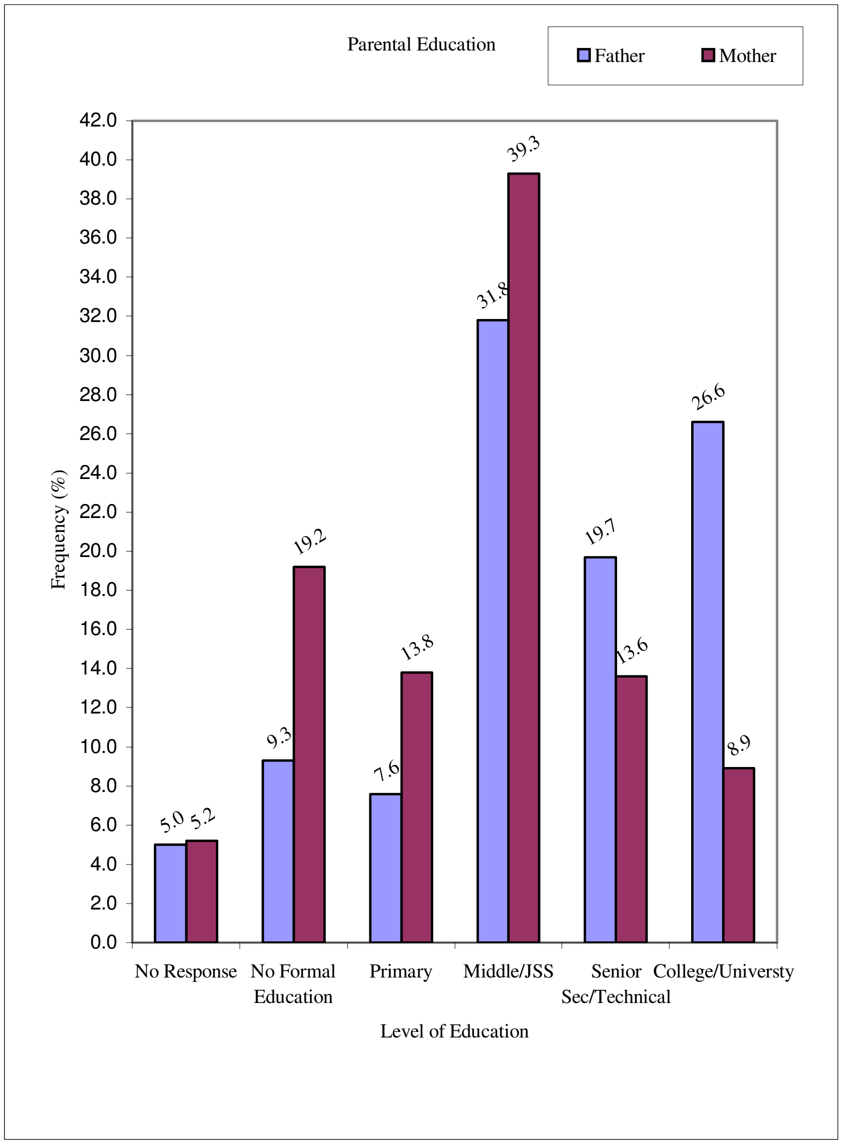

Figure 6-3. Percentage for parental education as indicated by pupils.

As mentioned earlier, the number of books at home has been used as proxy measurement or indirect indicator of parental education and household wealth, as suggested and tried by Hauser and Warren (1997). As high as 532 (51.8%) and 227 (22.1%) of the pupils reported having only from one to ten and eleven to fifty books respectively at home (see figure 6-5).

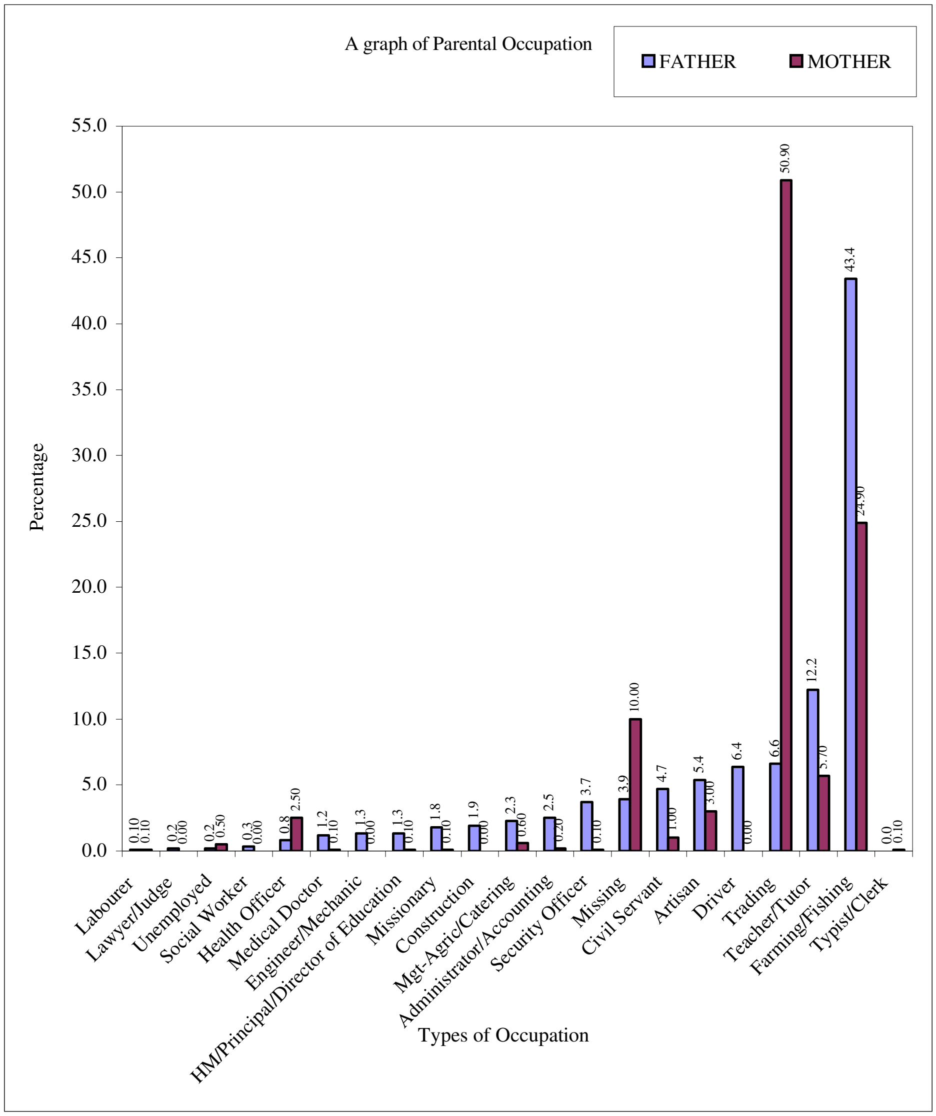

Figure 6-4. Parental occupation as indicated by pupils. Fathers' occupation is charted in ascending order of percentage of frequency.

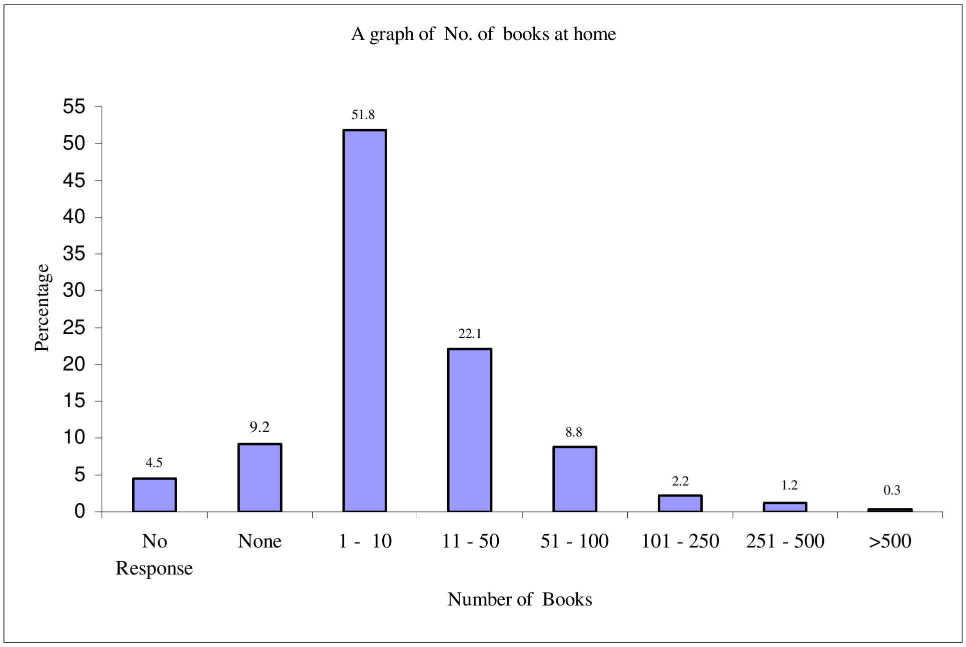

Figure 6-5. Percentage of pupils responding to range of number of books at home.

6.3 Discussion

6.3.1 Sample characteristics

The span of age of JSS3 pupils in this study was 10 to 23 years. The presence of over-age pupils at this stage of schooling and also beyond the age range cohort of ROSE project study (14-16 years) is not an uncommon occurrence in developing countries. It is mostly marked in the rural areas in Ghana. For example, the sample in this study showed the following range of ages. The ages of pupils in urban areas ranged from 10 to 19 years, with a mean of 15.06 years and standard deviation of 1.33, whereas the pupils in rural areas ages ranged from 10 to 23 years, with a mean age of 15.40 years and standard deviation of 1.53. The presence of over-age children in schools in less-developed countries and in particular, rural areas have also been noted by Towse *et al*. (2005). A study conducted by Towse and his colleagues with the third year Ghanaian junior secondary pupils revealed that they were aged from 11 to 27, with a mean age of

15.5. In the same sample it was noted that, there were a number of factors that contributed to pupils with age well above the expected age of 15 years. Among the factors are:

- many pupils in deprived regions (especially in the rural areas) enter Primary 1 when they are above the statutory age of six years as a result of both the long distances from school and poverty;
- there is a high repetition rate at the primary level; and
- a large number of drop-outs re-join the school system later on.

According to Towse and his colleagues, most often pupils drop out of school to assist parents in their economic activities as a way of contributing to their family incomes, and later re-join the school system. Schooling is perceived to be unimportant due mainly to the pupils' and parents' awareness of unemployment of school leavers against real incomes which are realized by school children from hawking. This encourages pupils of low income families to drop out of school. Pregnancy has also been a major cause of dropout among adolescent JSS girls and that one in every two dropouts would likely return to school and complete the basic education (Boakye *et al.*, 1997). According to Boakye *et al.*, the pregnancy among adolescent JSS girls could be as a result of parental irresponsibility and poverty as well as the dropouts' biological desires and ignorance of the reproductive system.

On the other hand, many parents in urban areas send their children to the nursery and kindergarten schools. As such, some children are able to enter Primary 1 from the age of 4 and are likely to receive rapid promotion due to a better foundation. This might be one of the reasons for the presence of some pupils with ages below 14 years. A pupil with an age of 10 years in JSS3, by a simple calculation, appears to be far from the stated age and might be a mistake on the part of a pupil.

Considering the sample characteristics by gender and geographical location, it is evident that there was clear disparity in the enrolment numbers for boys and girls.

A similar pattern was found for rural and urban (see fig.6-2). The sample population showed lower enrolment levels for both girls (46.3% as against 53.7% for boys) and for pupils in rural schools (40.3% as against 59.7% for urban). According to Anamuah-Mensah (1995), statistics on females in education in general indicate that female participation decreases sharply as one climbs the education ladder. Anamuah-Mensah also reveals that on the average, there is a sharp drop from Primary to JSS and even a shaper drop from JSS to SSS (Senior Secondary School). The dropout rate is greater on the average for girls than boys.

There are some factors that hinder the education of both the girl-child and rural-child. Poverty is seen to be the most obvious factor affecting girls' and rural school pupils' participation in education in general. Many rural schools in the sample area appear to be in poverty-stricken and marginalized environments, where parents because of their socio-economic status, find it difficult to support their children at school. They may prefer educating the girl-child to boy-child. Early childhood pregnancy, perception of school as unimportant economically, poor academic performance, some cultural practices and punishment by teachers have also been identified by Boakye *et al.* (1997) as some of the causes of dropout in Ghana. These factors appear to hinder the girl- and rural-child's access to education more than boy- and urban-child as seen in figure 6-2.

6.3.2 The socio-economic status (SES) of parents

It is evident from figure 6-3 that the gender differences on parental education were more pronounced. There seems to be an interesting pattern. Most of the mothers had lower education, which may be seen as a general trend in the country. Only 91 (8.9%) of mothers had a college or university education. The attainment of higher education for mothers was low in the sample area. There may be many contributing factors to the low educational level of mothers. Mothers may:

- at their school-going ages not have been given an equitable access to education;

- have dropped out of school as a result of early childhood pregnancy; and
- have equally poorly educated parents themselves and might have lacked motivation to study.

Fathers equally had low education in this study area. About 327 (31.8%) of fathers had middle or junior secondary school education. However, there were a considerable number of fathers than mothers who had attained higher education. Implicit in this finding is that most children of these parents may lack motivation to learn, since parents are not likely to be role models for them.

Although, trading and farming were the most dominant occupations with respect to mothers, most of them were petty traders, and subsistence farmers. This might not raise the required financial resources for persistence in science learning and learning in general. Only 125 (12.2%) of fathers were in the teaching profession, 66 (6.4%) drivers, 55 (5.4%) and 48 (4.7%) were artisans and civil servants respectively (see figure 6-4). The finding shows that percentage of children in families with scientists who can help the children is significantly small. There is a substantially greater chance that a child of such background will be hesitant about pursuing science and science related field. This is because parents cannot serve as positive examples to their children.

Considering that the reflection-level needed by the respondents for the item on number of books at home is adequate. It is evident that, the result from the responses on this item then confirms the low educational level and socio-economic status of the survey area (see figure 6-5).

Conclusion

There was a clear disparity in the enrolment numbers for boys and girls, when one considers sample characteristics by gender. A similar pattern was found for pupils in the rural and urban areas. The sample population showed lower enrolment levels for both girls and for pupils in rural schools.

Poverty is suggested in this study as the most obvious factor affecting girls' and rural school pupils' participation in education in general. Many rural schools in the sample area appear to be in poverty-stricken and marginalized environments. Parents in such environments may find it difficult to support their children at school. They may prefer educating the girl-child to boy-child.

In the chapter 7 to chapter 12, I will address the research questions in the order in which they were outlined in section 1.3.3. I will present the results and discussions in sections. The research questions that were formulated based on the themes for the subsets of ROSE questionnaire are:

- What do children in Ghana want to learn about in science?
- What views do these children hold about environmental challenges?
- How do these children relate to school science?
- How do these children look at various aspects of the role of science and technology in society?
- What are the priorities of these children towards potential future occupations or jobs?
- What kinds of science-oriented experiences do these children have from their lives outside schools?

I will also look at these questions from gender, rural-urban and international perspectives.

7. WHAT THE CHILDREN WOULD WANT TO LEARN ABOUT IN SCIENCE

7.1 Introduction

In most developed countries, many young people appear to lose interest in science and technology in schools and further studies (Black and Atkin, 1996). Several contributing factors have been advanced for pupils' declining interest in science during their school careers in developed economies .One of such factors has been the apparent lack of relevance of the school curriculum to teenagers' curiosity and interest (Millar and Osborne, 1998). Whatever the reasons for this phenomenon are, Ghana, as a developing country, cannot afford to follow the same trend. Ghana, like many of African countries, continues to be faced with challenges of underdevelopment. This makes it important that science and technology education should attract the attention of Ghanaian school children. One way of doing this is to know the interests of the pupils in relation to science and technology education and how this may vary with their background. When such interests are considered in the process of designing science curricula, it is likely to make school science relevant to the needs of all learners and their communities.

An important goal of this chapter is to identify interesting science content knowledge for gender-inclusive, as well as urban/rural-inclusive science education within the compulsory school level in Ghana. In order to get a balanced view of how different groups of pupils' voices are heard is to investigate what pupils are likely to have interest to learn about.

A group of 108 items under the question 'What I want to learn about' which might be included in a science curriculum was used to obtain information about what interesting topics pupils want to learn about. There are three sections of the questionnaire entitled ‘What I want to learn about’. Items ACE are under this title. The three sections invite pupils to give answers to a series of questions about what they would like to learn and they indicate their levels of interest on a 4-point Likert-type scale rating. The rating runs from ‘Not interested to Very interested’. The set of topics is chosen to reflect different aspects of science. These topics are on the 'mechanical' aspects (like how car engines work), the social/health aspects (like food to eat and exercise of body) and those that relate to natural phenomena (like earthquakes or rainbows).

7.2 Assessing the effect of the outliers on the data

The range for the age cohort being studied is 14 to 16 years. However, as mentioned, there were ages well outside this range that may be a factor in their responses. In order to establish the quality of the data for this study due to the presence of outliers (cases with values well above or well below the majority of other cases), I scrutinized the effect of the responses of the over-age and under-age pupils in the sample on the data.

As a way of checking for a possible effect of the outliers on the data, I determined the overall mean of the ACE items, as an example, for all the respondents. The mean of the ACE items for the target age range cohort (14-16) was also determined. The mean for all respondents and that for the cohort were 2.86 and 2.87 respectively. The mean difference is not significant enough to alter the results. Therefore, all the respondents were included in the dataset for the analysis.

7.3 Comparison of responses based on ‘neutral’ position

Pupils were invited to respond to questionnaire statements by picking an option on a 4-point Likert-type scale rating, ranging, for example, from ‘Not interested’ to ‘Very interested’. The mean values for each theme (subset) were determined to give the overall picture of general preference levels for boys and girls, as well as rural and urban pupils. Within the themes, the mean value of each statement/ topic was found. These are presented in tables and figures, starting with pupils' most preferred statement (most interesting, most important and most agreed) to the least. The standard deviations depicting how the scores are distributed around the mean values were mostly reported in the tables at the Appendices B, C, E, F, G, H and I.

The middle point of the scale is regarded as a mean score of 2.5, and may represent a 'neutral' position. For the H items, it represents the mid-point of the scale since the scale ranges from "Never" to "Often". The value representing a 'neutral' position was used in this study to indicate a position in their responses where respondents, for an example, are neither interested nor disinterested with a statement. A mean value above or below 2.5 gives a general picture of interest or disinterest among pupils with a statement. This was done to make comparisons of different profiles very simple and straightforward. However, it must be noted that a mean value above or below 2.5 does not imply that all pupils may be interested or disinterested with a statement, but the majority are.

7.4 Results

Overall mean score for all the ACE items and mean score for each variable were calculated. There was a general high level of interest in all the science topics with mean value of 2.86. An overall high level of interest in almost all the science topics was also found for all groups of pupils. An overall mean value for girls was 2.85, with mean values ranging from 3.48 to 2.12. That for boys was 2.86 and ranging from 3.47 to 2.18. When geographical background (urban/rural) was considered, the overall mean for urban school pupils was 2.84 and had a range from 3.52 to 2.09. The overall mean for rural was found to be 2.89, and the mean value of each topic was between values of 3.46 and 2.10. There were essentially no large differences between boys and girls as well as urban and rural school pupils in the measure of overall interest (boys=2.86 and girls=2.85; urban=2.84

and rural=2.89). The neutral response value is 2.5. The mean scores for each variable were also found for boys and girls separately, so were those for urban and rural school pupils (see Appendices B and C).

In order to shed light on pupils' interests in science subject areas, some of the science topics were grouped into components of science subjects or disciplines that are taught in the JSS general science course in Ghana. Although, some of the items on the list of topics of interest do not appear in similar forms in the general science syllabus, an effort was made to cluster the items to give an overall picture of where the items could fit into the traditional science curriculum. The selected items were put into the traditional science curriculum content areas (physics, chemistry, biology, agricultural science and health science). Some of the items were also grouped as belonging to different contexts of science subjects. Due to the current trends and issues in science education, environmental education and technology education, which are not directly taught in the Ghanaian JSS, had been included as subject areas. Some of the items may also seem controversial and unusual in science educational context, for example, items regarding ghosts, horoscopes, mind-reading, clashes between science and religion. Such items may be addressing topics far outside the traditional science curriculum. Therefore not all the items could be clustered into content or context areas of the subjects. A couple of items by their nature could fit into another cluster as well.

The clustering was done by adopting the chart in Schreiner and Sjøberg (2004) for classifying those items into content and context areas of science courses. The science subjects in content and context that were classified are technology education, health science (health enhancement), physics (context), human biology, physics (content), agricultural science, and environmental education. The rest are botany, chemistry (context), chemistry (content), health science (health risk) and zoology.The items were 'hand picked' into these possible clusters of items and their internal consistency were verified based on

Cronbach's alpha. The Cronbach's alpha values ranged from 0.501 to 0.781[15] (for more details, see Appendix D).

The mean values for content and context areas of science subjects were determined for boys and girls, as well as for urban and rural school pupils. These are presented in figures 7-1, 7-2, 7-4 and 7-5.

7.4.1 Boys' and girls' science topics of interest

The most popular topics for boys and girls are presented in Table 7-1. Table 7-2 shows the least popular topics for boys and girls. Mean values are given. The scale ranges from 1 (not interested) to 4 (very interested). The complete series of results are given in Appendix B.

It is very noticeable that boys and girls were selecting similar interesting or unappealing topics (Table 7-1 and Table 7-2). An overall high level of interest in almost all the science topics was found for both genders, with mean values ranging from 3.48 to 2.12 for girls and 3.47 to 2.18 for boys.

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[15] As mentioned earlier, Nunnally (1978) recommends minimum Gronbach alpha level of 0.7 with a higher value indicating greater reliability. Some of the items on the science related topics of interest were clustered with specific purpose of putting them into different content and context areas of science subjects that are likely to fit into the JSS science curriculum. Some of the clusters' alpha values were below 0.7 indicating an unsatisfactory internal consistency and might not require a further analysis. However, my main interest only lies in the overall picture of where those topics would fit in the General Science syllabus, hence, analysis was also done on those clusters which fell below the cut-off alpha value. For the purpose of evaluating the pupils' interests in science subject areas, those clusters must be granted the condition of being quasi-reliable. However, according to Gable and Wolf (1993), high reliabilities are necessary when results are meant for making decisions about individuals, but for groups of respondents, lower reliability is accepted such as a reliability of 0.5.

Table 7-1. The top ten of the most popular topics for girls and boys in Ghana. Mean values sorted in descending order. Items appearing in both lists are in boldface.

Girls' topics	Mean
C7 How computers work	**3.48**
E5 What can be done to ensure clean air and safe drinking water	**3.48**
E23 How my body grows and matures	**3.47**
A37 What to eat to keep healthy and fit	**3.47**
A40 How to exercise to keep the body fit and strong	**3.44**
C6 How mobile phones can send and receive messages	**3.40**
A36 How the eye can see light and colours	3.37
E27 Electricity, how it is produced and used in the home	**3.36**
E11 What we know about HIV/AIDS and how to control it	**3.33**
A15 How plants grow and reproduce	3.26

Boys' topics	Mean
C7 How computers work	**3.47**
E23 How my body grows and matures	**3.46**
A37 What to eat to keep healthy and fit	**3.45**
E5.What can be done to ensure clean air and safe drinking water	**3.45**
A40 How to exercise to keep the body fit and strong	**3.44**
C6 How mobile phones can send and receive messages	**3.44**
C5 How things like radios and televisions work	3.41
E27 Electricity, how it is produced and used in the home	**3.41**
E11 What we know about HIV/AIDS and how to control it	**3.37**
E9 Sexually transmitted diseases and how to be protected against them	3.35

Table 7-2. The ten least popular topics for girls and boys in Ghana. Captions, as in Table 7-1.

Girls' topics	Mean
A41 Plastic surgery and cosmetic surgery	**2.43**
C12 Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	**2.35**
C10 Unsolved mysteries in outer space	**2.34**
A14 Dinosaurs, how they lived and why they died out	**2.34**
A38 Eating disorders like anorexia or bulimia	**2.31**
A27 Brutal, dangerous and threatening animals	2.30
A25 Tornados, hurricanes and cyclones	**2.28**
A22 Black holes, supernovas and other spectacular objects in outer space	**2.24**
A12 Cloning of animals	**2.19**
C14 Ghosts and witches, and whether they may exist	**2.12**

Boys' topics	Mean
A41 Plastic surgery and cosmetic surgery	**2.42**
C10 Unsolved mysteries in outer space	**2.32**
A12 Cloning of animals	**2.30**
A39 The ability of lotions and creams to keep the skin young	2.26
C12 Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	**2.24**
A14 Dinosaurs, how they lived and why they died out	**2.20**
A38 Eating disorders like anorexia or bulimia	**2.18**
A22 Black holes, supernovas and other spectacular objects in outer space	**2.18**
C14 Ghosts and witches, and whether they may exist	**2.17**
A25 Tornados, hurricanes and cyclones	**2.15**

Boys' and girls' interests in science subjects

The figures 7-1 and 7-2 are graphs showing science subjects in both content and context areas for which boys and girls respectively, had expressed interests in them.

The findings are presented in such a way that the subject that appeals most to pupils is presented first and the one considered least interesting is at the bottom in the figures.

From figures 7-1 and 7-2, it is noticeable that both genders were interested in content and context areas in all the science subjects. The mean values ranged from 3.14 to 2.69, with an overall mean of 2.91 for boys. The four top ratings in science subjects for boys, starting with the most preferred are technology education, physics (context), health science (health enhancement) and human biology, [mean: 3.14-2.97]. However, chemistry both in content and context, health science (human risk) and zoology are at the bottom of the list of subjects, [means: 2.81-2.69].

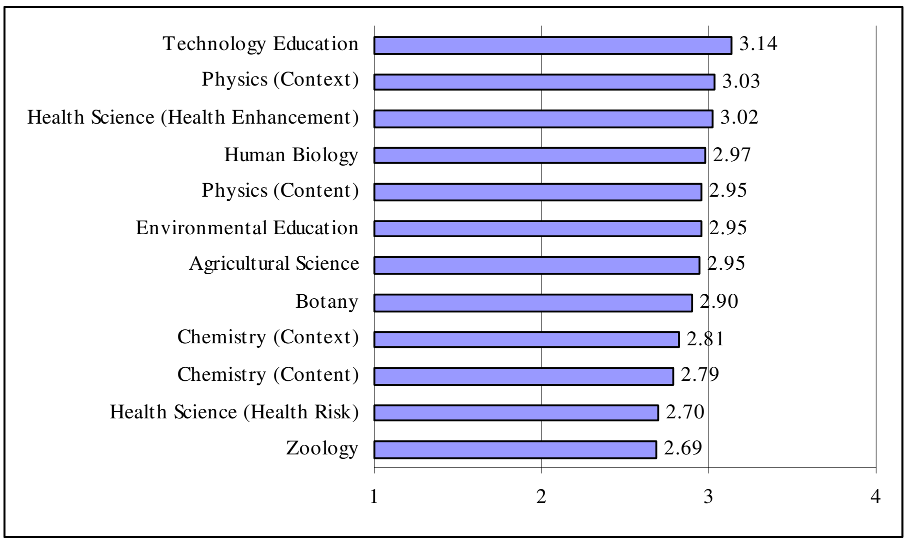

Figure 7-1. Boys' science subjects of interest. Mean values for clusters are given. The scale ranges from 1 (not interested) to 4 (very interested).

For girls, the overall mean was 2.88, and the mean values were from 3.04 to 2.64. The four most preferred subjects were technology education, health science (health enhancement), physics (context), human biology, [means: 3.04-2.64]. The least preferred subjects were chemistry in the areas of both content and context, health science (health risk) and zoology, [mean: 2.80-2.64].

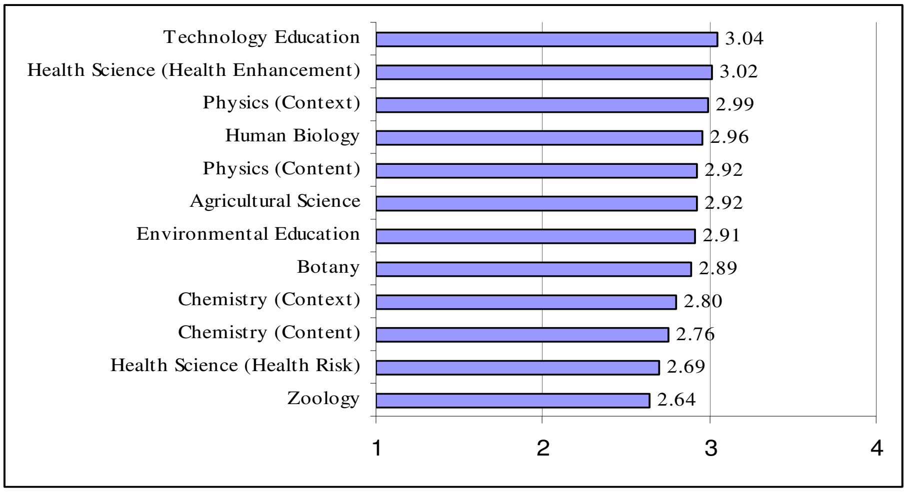

Figure 7-2. Girls' science subjects of interest. Captions, as in figure 7-1.

7.4.2 Gender differences in pupils' topics of interest

As it is mentioned earlier, the import of this study is to investigate gender, as well as geographical background differences in pupils' experiences, interests, opinions, and future aspirations towards school science.

The distribution of preference levels among both groups of pupils showed some differences. A high level of preference for a given statement (item) by one group could also be of high preference for the other. It is important to note that members of both groups may report high preference levels in some of the items, but to some extent might differ in the degree of preference in items. This must be seen in the light of differences between boys and girls. With large samples, like we have in ROSE, even very small differences between means of groups can become statistically significant. This does not mean that the difference has any practical, theoretical or educational significance (Pallant, 2001). However, it is noteworthy commenting on the differences in order to characterize different interest profiles. The items with statistically significant differences ($p<0.05$) are commented on.

Table 7-3 focuses on gender differences. I will focus on differences between boys' and girls' responses that are statistically significant. Some insight into gender differences in responses is found in Appendix B. Only 17 responses from boys and girls were statistically different (see table 7-3). In the table, the list is sorted in ascending order for the difference, where the boys' mean is subtracted from the girls' mean. The p-value in the last column is a measure of the statistically significance of the difference. Only items with statistically significant ($p<0.05$) gender differences are given in the table.

For girls, the priorities were with topics that relate to the self (beauty) and, in particular health and well-being. The boys, on the other hand, had their interests reflecting on topics that deal more with practical and mechanical aspects of science.

Table 7-3. Statistically significant gender differences in science topics. Mean values are given for girls and boys, with standard deviation (SD) and p-value. The p-values of topics in favour of girls are in boldface. Mean differences between girls and boys sorted in ascending order.

	Girl	Boy	Mean Difference	
Topics	Mean (SD)	Mean (SD)	(girls-boys)	p-value
Rockets, satellites and space travel	2.78(1.08)	3.01(1.08)	-0.23	0.001
Sex and reproduction	2.71 (1.18)	2.92 (1.12)	-0.21	0.003
The use of satellites for comm. and other purposes	3.05 (1.00)	3.25 (0.93)	-0.2	0.001
How petrol and diesel engines work	2.84 (1.03)	3.03(0.98)	-0.19	0.003
Optical instruments and how they work (telescope, camera, microscope, etc.)	3.14 (0.95)	3.32 (0.89)	-0.18	0.002
How things like radios and televisions work	3.25 (0.92)	3.41 (0.81)	-0.16	0.005
Inventions and discoveries that have changed the world	2.78 (1.01)	2.93 (1.02)	-0.15	0.029
Stars, planets and the universe	3.10 (1.01)	3.24 (0.96)	-0.14	0.028
The ozone layer and how it may be affected by humans	2.70 (1.09)	2.84 (1.09)	-0.14	0.047
How to use and repair everyday electrical and mechanical equipment	3.05 (0.91)	3.19(0.96)	-0.14	0.022
How the human body is built and functions	3.17 (1.01)	3.29 (0.93)	-0.12	0.048
Phenomena that scientists still cannot explain	2.76 (1.13)	2.68 (1.15)	0.08	**0.028**
Risks and benefits of food additives	2.80 (1.05)	2.67 (1.05)	0.13	**0.045**
Symmetries and patterns in leaves and flowers	2.74 (1.11)	2.59 (1.08)	0.15	**0.031**
How radioactivity affects the human body	2.64 (1.07)	2.47 (1.15)	0.17	**0.027**
Properties of gems and crystals and how these are used for beauty	2.76 (1.05)	2.53(1.05)	0.23	**0.001**
The ability of lotions and creams to keep the skin young	2.52 (1.14)	2.26 (1.12)	0.26	**0.000**

7.4.3 Urban and rural school pupils' topics of interest

The data have also been analyzed in the same way from an urban/rural perspective, which is an important indicator in many countries, in particular developing countries. The results are given in Tables 7-4 and 7-5. Mean values are given. The scale ranges from 1 (not interested) to 4 (very interested). The items appearing in both lists for urban and rural pupils are in boldface. This is done for top ten most popular and least popular topics. Full results are given in Appendix C.

It is also noteworthy that the urban and rural school pupils had almost similar preferences for the science topics. They had similar interest or unappealing topics (Table 7-4, Table 7-5 topics in boldface). Most pupils showed high level of interest in almost all the science topics, with mean values ranging from 3.52 to 2.09 for urban pupils and 3.46 to 2.10 for rural.

Table 7-4. The top ten of the most popular topics for urban and rural school pupils in Ghana. Captions, as in Table 7-1.

Urban pupils' topics	Mean
C7. How computers work	**3.52**
E5. What can be done to ensure clean air and safe drinking water	**3.51**
A37. What to eat to keep healthy and fit	**3.49**
E23. How my body grows and matures	**3.48**
A40. How to exercise to keep the body fit and strong	**3.47**
C6. How mobile phones can send and receive messages	**3.40**
A27. Electricity, how it is produced and used in the home	**3.39**
A36. How the eye can see light and colours	3.38
E11. What we know about HIV/AIDS and how to control it	**3.36**
C5. How things like radios and televisions work	**3.35**
Rural pupils' topics	Mean
C6. How mobile phones can send and receive messages	**3.46**
E23. How my body grows and matures	**3.44**
A37. What to eat to keep healthy and fit	**3.41**
E5. What can be done to ensure clean air and safe drinking water	**3.40**
A40. How to exercise to keep the body fit and strong	**3.40**
C7. How computers work	**3.39**
E27. Electricity, how it is produced and used in the home	**3.39**
E11. What we know about HIV/AIDS and how to control it	**3.35**
C5. How things like radios and televisions work	**3.32**
A15. How plants grow and reproduce	3.30

Table 7-5. The ten least popular topics for urban and rural school pupils in Ghana. Captions as in Table 7-1

Urban pupils' topics	Mean
A27. Brutal, dangerous and threatening animals	**2.33**
C10. Unsolved mysteries in outer space	**2.32**
A41. Plastic surgery and cosmetic surgery	2.28
A12. Cloning of animals	**2.26**
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	**2.24**
A14. Dinosaurs, how they lived and why they died out	**2.21**
A38. Eating disorders like anorexia or bulimia	**2.21**
C14. Ghosts and witches, and whether they may exist	**2.18**
A22. Black holes, supernovas and other spectacular objects in outer space	**2.12**
A25. Tornados, hurricanes and cyclones	**2.09**
Rural pupils' topics	Mean
A27. Brutal, dangerous and threatening animals	**2.43**
A25. Tornados, hurricanes and cyclones	**2.38**
A22. Black holes, supernovas and other spectacular objects in outer space	**2.37**
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	**2.37**
C10. Unsolved mysteries in outer space	**2.34**
A14. Dinosaurs, how they lived and why they died out	**2.34**
A38. Eating disorders like anorexia or bulimia	**2.31**
A39. The ability of lotions and creams to keep the skin young	2.26
A12. Cloning of animals	**2.23**
C14. Ghosts and witches, and whether they may exist	**2.10**

Urban and rural school pupils' interests in science subjects

The figures 7-3 and 7-4 are graphs representing science subjects in their content and context areas that resulted from the clusters of some of the topics from the listed science topics of interests for urban and rural pupils respectively. The subjects are presented with most interesting at the top and least interesting at the bottom.

As it is expected, both urban and rural school pupils expressed interest in the entire list of subjects, but with mixed order. It is evident from Figures 7-3 and 7-

4 that all the mean values were higher and greater than 2.5, the neutral position. For urban school pupils, the mean values ranged from 3.09 to 2.65 and overall mean was 2.88. When responses from pupils in rural schools were analyzed, the overall mean was 2.92 and the mean values were from 3.10 to 2.69. Among the twelve listed science subject areas, technology education tops the list of preferred subject areas and zoology stays at the bottom for all groups of pupils. When specific interest profiles were considered, the urban school pupils on the average, were most interested in technology education, health science (health enhancement), physics (context) and human biology; and least interested in chemistry (content and context), health science (health risk) and zoology. The rural school pupils' most interesting subjects were in a mixed order as compared to those of urban school pupils. The most interesting subject areas were also technology education, physics (context), agricultural science and health science (health enhancement). The least interesting subjects were similar to those of the urban school pupils.

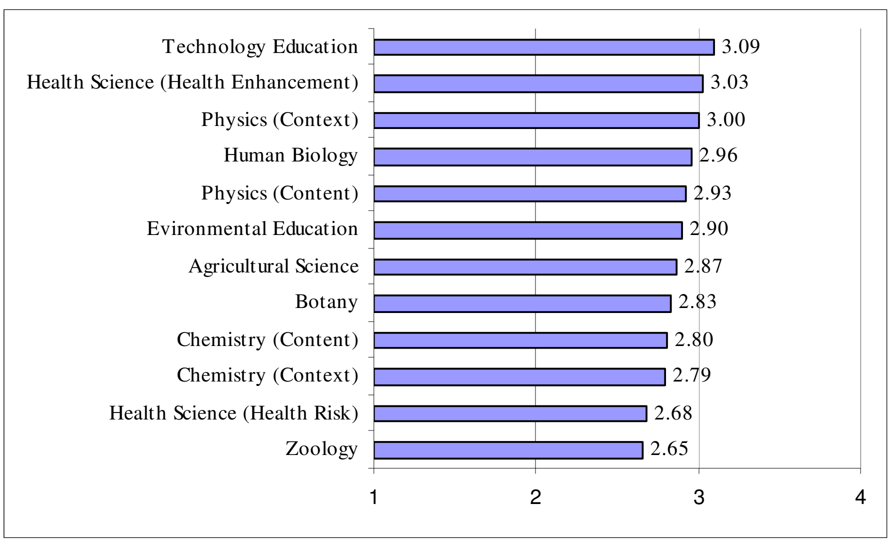

Figure 7-3. Urban school pupils' science subjects of interest. Captions, as in figure 7-1.

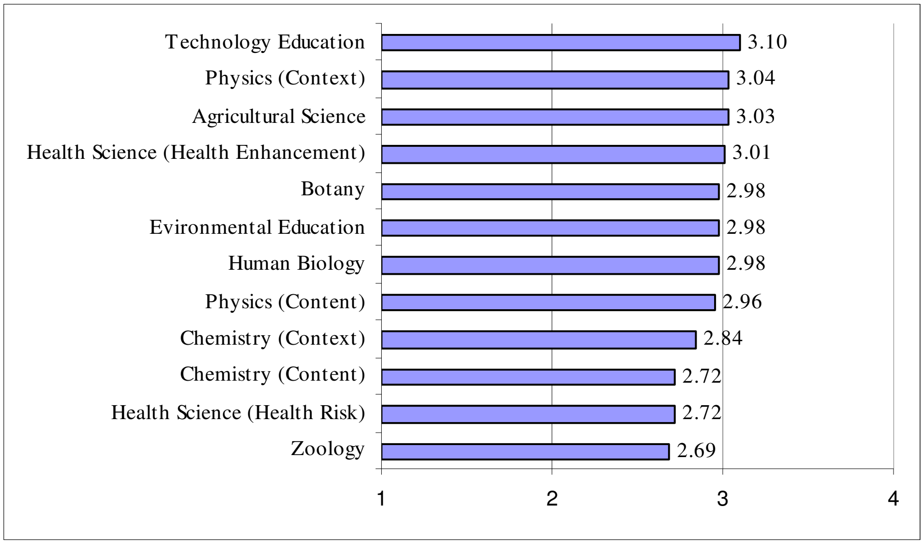

Figure 7-4. Rural school pupils' science subjects of interest. Captions, as in figure7-1.

7.4.4 Urban and rural school pupils' differences in topics of interests

The analysis of the data for urban/rural pupils is given in Appendix C. The list of topics is sorted by urban/rural difference in ascending order. Statistically significant differences are in boldface. Negatives are in favour of rural school pupils. There were statistically significant differences between urban and rural school pupils' mean responses on a number of the selected science topics. However, there was no clear pattern emerging from these differences. A detailed discussion on the differences in urban/rural pupils' interesting science topics is provided in section 7.6.3.

7.5 International comparison

This section monitors some views, values and attitudes (affective experiences) held by the Ghanaian pupils against the background of other pupils across different cultures (countries) as they engage in school science. "All the countries" used in this study refers to countries that are partners to the international ROSE project, which were selected in this study to serve the purpose of the international comparison.

My approach to the comparison was that I picked Ghanaian pupils' four most appealing statements of the issues raised in the ROSE questionnaire relating to responses to each of the six research questions that appear on the lists of both genders. These were compared to the views of pupils in different countries about those statements. The urban and rural pupils' interests in those issues were not considered in this comparison, because the respondents in those countries were not categorized into geographical locations in each country. The graphs used for the illustrations of the views across countries were generated by the ROSE partners in Norway, but the graphs were purposively edited where necessary.

7.5.1 Ghanaian pupils' topics of interest as compared to that of pupils from other countries

When pupils were to indicate how interested they were in learning about a variety of science topics in question ACE, the responses showed varying national mean scores to each of the items across countries. This is illustrated in figure 7-5, with four examples of the statements presented in diagrams, which Ghanaian pupils had reported of having high interest in them. These are: *How computers work; How my body grows and matures; What can be done to ensure clean air and safe drinking water and What to eat to keep healthy and fit*. The responses to the statement 'how computers work' indicated that in the low HDI countries, most pupils were more interested in learning about it (mean scores were 3.5 and above), with similar interest for boys and girls. However, among the low HDI countries, Ghana showed the least interest. The interest was followed in decreasing order by the medium HDI countries and also the gender differences started to show within these countries. The gender difference became pronounced in the high HDI countries. Among all the countries, on the average, the majority of pupils in the high HDI countries showed the least interest to learn about how computers work. Girls, in the high HDI countries appeared to show no interest in it, especially girls from the Scandinavia countries.

Similar pattern was seen in the responses to the statement ‘how my body grows and matures’. The gender difference showed clearly within all countries, except Ghana. The gender difference was more pronounced in the high HDI countries and the mean scores for boys in these countries appeared closer to the neutral response score line, showing indifference to this topic. However, the majority of girls in all countries were enthusiastic in learning about it.

The responses to the statement ‘what can be done to ensure clean air and safe drinking water’ indicated an expression of a very high level of interest to learn about this topic for most of the pupils in the low HDI countries. Furthermore, as the level of development in a country increases their interests in this topic was found to decrease. However, the gender differences appeared less pronounced in many of the countries. Most of the boys in the high HDI countries tended to show no interest in the topic.

The statement ‘what to eat to keep healthy and fit’ appealed to pupils in almost all countries, but most boys in the highly developed countries appeared unwilling to learn this topic. In all countries, the majority of girls were found to have more interest than boys in learning about things to eat to keep healthy and fit, though, at varying levels. But the gender differences were largest in the high HDI countries.

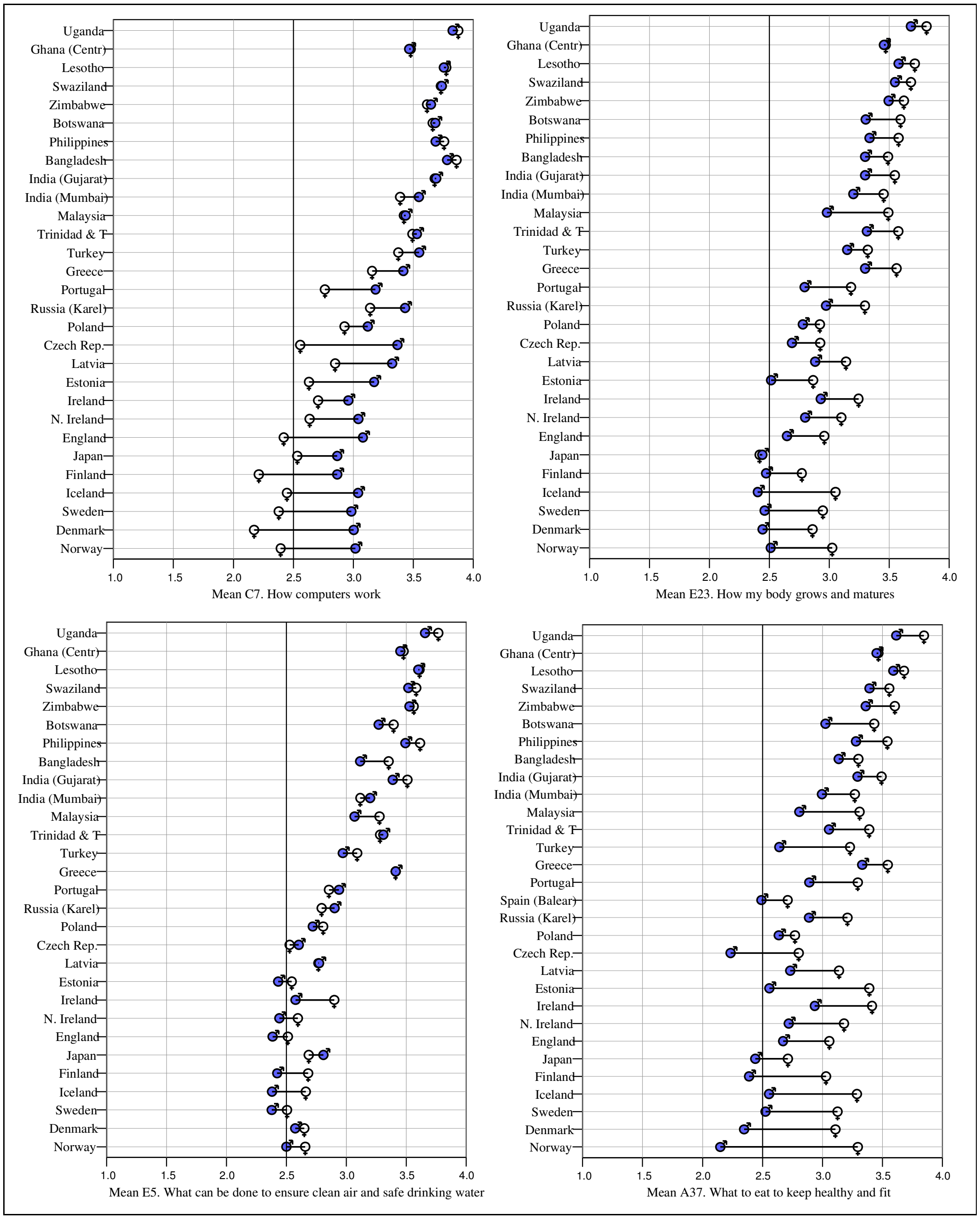

Figure 7-5. Illustrative examples of the pupils' science topics of interests across countries. Average national scores for boys (filled symbols) and girls (open symbols). "Trinidad & T" (T for Tobago). Words in bracket behind some countries indicates sample region.

7.6 Discussion

7.6.1 Boys' and girls' science topics of interest

It is evident from Table 7-1 and Table 7-2 that boys and girls had interests that did coincide for both appealing and unappealing topics. It also appeared Ghanaian pupils, both boys and girls were interested in learning about almost all the topics in the questionnaire, when one considers the mean range for the boys and girls. The mean values were significantly high. These values are consistent with the results obtained for many developing countries from the SAS study and others. In those studies, mean values for the developing countries were found to be higher than the developed countries (Sjøberg, 2000b; Sjøberg and Schreiner, 2005a).

A likely explanation for these observations may be that in Ghana, and other developing countries, education in general is not very accessible to all children. Inaccessibility may be due to some cultural practices, lack of logistics and financial resources. Educating girls as compared to that of boys is seen to be luxurious. In this regard girls continue to be disadvantaged in accessing education. Ghanaian pupils are likely to show their curiosity about learning most of the science topics listed. Motivation to study science might be high for both genders. As can be seen from table 7-1, the 'top ten' topics are not very different for boys and girls. The list reflects strong interests in topics that relate to the self, especially to health and well being. It seemed that girls and boys agreed on the importance of learning about diseases, such as HIV/AIDS, adequate nutrition, food security, good sources of drinking water and good health. These topics are of personal and societal relevance and reflect some of the challenges facing most of African countries, including Ghana.

These results seemed to suggest that Ghanaian pupils see most of the topics very important to learn in school science. The results also showed little variation in interests towards these topics for boys and girls. For example, 'What can be done to ensure clean air and safe drinking water', 'What to eat to keep healthy and fit', 'How to exercise to keep the body fit and strong'. It is noticeable that a strong interest in a given topic was the same for both genders. Pupils of both genders were also strongly attracted by topics that can be described as modern technology, for example, 'How computers work' and 'How mobile phones can send and receive message'. The majority of pupils who responded to the questionnaire seemed to have no access to these types of technology, neither at school nor at home. The strong interests in such topics might have some elements of fascination for most pupils. It is also noteworthy to see that both genders showed high levels of interest in learning about HIV/AIDS and how to control it and 'what to eat to keep healthy and fit’. These topics also have high relevance to the life styles of the learners and could attract the attention of both boys and girls. On the contrary, girls showed strong interest in biology-related topics such as ‘How plants grow and reproduce’. This confirms the findings of many studies, which indicate that traditionally, girls would want to learn about topics in biology (see for example Kahle and Meece, 1994, Anamuah-Mensah, 1995, Rennie *et al*., 1996, Sjøberg, 2002c).

As mentioned earlier, girls’ lack of interest for physics can not be generalised for all the topics in physics. There are some topics in physics that appeal to girls. In this study, for example, girls did show interest in some topics such as ‘How the eye can see light and colours’ and ‘Electricity, how it is produced and used in the home’. These topics are found among the ten most appealing topics for girls; however, these topics are not of more mechanical aspects of physics. A mechanical aspect of physics, like ‘How things like radios and televisions work’ for which boys had indicated their strong interest was not shared with the girls among the ten most interesting topics. This is in line with the findings of Osborne and Collins (2001). In their study, they found among young English pupils that, girls do not share the boys’ interest in the physics related to cars and flight, but that they express some interest in light and electricity.

A similar pattern was found when we turn to Table 7-2, the topics that are ten least popular with the pupils. The overall picture was that the same topics were unappealing to both boys and girls. The mean scores were less than 2.5 on the 4-point Likert-type scale. 'Black holes, supernovas, and other spectacular objects in outer space', 'Ghosts and witches, and whether they may exist' were at the bottom of the list of popularity. Apart from the topic on ghosts and witches, almost all the ten least appealing topics for both girls and boys are either phenomena or processes in science, which might be perceived to be unfamiliar in the Ghanaian context. Both genders showed low levels of interest in learning those topics. This probably might be more to do with the question of familiarity rather than relevance. The content on the Universe in the JSS general science syllabus is limited to planets, causes of day and night, and seasons. Phenomena such as black holes, supernovas and comets are not highlighted. Myths about ghosts and witches are very common in Ghana. However, there is some element of speculation and uncertainty in their existence, with practically no personal and societal relevance and also non-scientific phenomenon to learn about. It is interesting to note that most pupils did not consider this to be a topic they would like to learn at school.

Boys' and girls' interests in science subjects

Both boys and girls in Ghana seemed to have interest in all the science subjects that resulted from the clusters of some of the science topics. The overall mean values were 2.91 and 2.88 for boys and girls respectively. This is in line with the findings from the SAS study (Sjøberg, 2000a, 2002b). In that study, Sjøberg revealed that in general pupils from developing countries appeared to be interested in learning about nearly everything. From figures 7-1 and 7-2, the picture is that both genders seemed to be interested in similar science subjects, though, to some varying degree. However, boys showed some higher level of interest when one considers the overall mean values. This confirms the findings from several studies elsewhere that show that boys have greater interest in science than girls (see for instance Clark 1972; McGuffin, 1973; Smithers and Hill, 1987).

General literature indicates that boys are found to be more interested in physical science and girls more interested in biological science topics. On the contrary, this study revealed that both genders shared the same interests in the science subjects (see figures 7-1 and 7-2).

Several studies have revealed that gender differences in the pupils' interests in science subjects exist (see Hoffmann, 1985; Dawson, 2000; Osborne and Collins, 2001; Colley *et al*., 2003). For this study, gender differences were not pronounced in the interest profiles for science subjects. Both boys and girls were going for technology education and physics, as well as biology.

A corresponding view to the general literature indicates that girls' lack of interests for physics can not be generalised for all topics in physics. There are some topics in physics that appeal to girls (see for instance, Osborne and Collins 2001). This has also been confirmed in this study. Girls in this study were found to share the boys' interest in the topics that are in the context area of physics. This similarity in interests might be due in part to the establishment of the STME clinics for girls since 1987 to promote the interest of girls in science, technology and mathematics education. The clinics might be yielding results that are helping the majority of girls to have interest in learning about most aspects of science. It may not be correct to come to a conclusion that biology is girls' subject and physics is a boys' subject. Even chemistry, which was found among the list of subjects of least interest, both genders preferred context. It is evident from the data that the same science content (in particular physics) may be put in different contexts that might attract the interest of girls to school science. It has also been indicated by Qualter (1993) that girls are likely to benefit from a more contextual approach to science teaching and learning. This may be a possible way to approach the concern about a more gender fair curriculum. This moves us, as science educators in Ghana, beyond the general statements about the interest profiles of girls and boys in relation to school science learning.

7.6.2 Gender differences in pupils' topics of interest

On the list in Table 7-3, for example, boys showed significantly higher enthusiasm for learning about 'How things like radios and television work', 'Optical instruments and how they work', 'The use of satellite for communication and other purposes', 'How to use and repair everyday electrical and mechanical equipment', 'How petrol and diesel engines work' and 'Rockets, satellites and space travel'. Almost all these topics are physical science (in particular physics) in nature and some practical aspects that include many of the fundamental areas of applied physics and engineering.

In contrast, girls reported more interest than boys in science that includes aesthetics and biology. Table 7-3 tells us that girls were significantly more interested in learning more about 'Properties of gems and crystals and how these are used for beauty', 'Symmetries and pattern in leaves and flowers', 'How radioactivity affects the human body', 'The ability of lotions and creams to keep the skin young' and 'Phenomena that scientists still cannot explain'. We note that these topics gear towards beauty, aesthetics, self and wonder. Some of them are related to biology.

The findings above accord that from earlier studies in many cultures (i.e. Clark 1972; Mc Guffin, 1973; Gardner, 1985 and 1998). This evidence also gives credence to results from the SAS-study (Sjøberg, 2000b).Although, there are exceptions to the perceived claim that boys are more interested in physical sciences and girls are more interested in the biological sciences, pupils' interests fit the gender stereo-typical patterns. Most boys were more interested to learn about some practical aspects of physical science while majority of the girls wanted to learn more about aesthetics and biology. The differences in this JSS boys' and girls' interests in some aspects of science appear to suggest that science content-related interests may begin early (see Jones *et al*., 2000). However, an interesting aspect in this study is that most of the topics were rather gender neutral. As stated earlier, only seventeen (17) out of the 108 topics had statistically significant different means for boys and girls, and all of these are presented in table 7-3.

7.6.3 Urban and rural school pupils' science topics of interest

We note that pupils from urban and rural schools had very similar preferences for the science topics. They had similar popular and unpopular interests (see Table 7-4 and Table 7-5). It is striking to note that as urban pupils expressed a very high level of interest to learn about 'How computers work', the rural pupils went for 'How mobile phones can send and receive messages'. Availability of educational resources in the home may have a great influence on motivation to learn or learning. In Ghana, a greater percentage of pupils lack access to resources, like computers, both at home and school (Anamuah-Mensah *et al.*, 2004). Mostly affected are the pupils from the rural areas. Almost all the rural areas in Ghana where this study was conducted were not connected to the national electricity network and therefore lack electric power, on which electronic devices like television or computer rely for its operation.

The choice of topic about computers as one of their preferences seems to suggest that most rural school pupils might have been informed about 'something' called computer and its usefulness, but have neither seen nor had an access to computers. Pupils in urban areas might have access to computers at the Internet cafes, and the privileged few may have access to computers at home. This might have influenced their expression of eagerness to learn about computers. The expansion of national communication network has made the mobile phones a commonplace object in Ghana. The use of mobile phones has become fascinating and also fashionable in both urban and rural areas. This leaves room for enjoyment and curiosity for pupils, especially those from rural areas, to know more about 'How mobile phones can send and receive messages'. It is also not surprising to note that the topic on 'How plants grow and reproduce' is on the list of most preferred topics by the rural school pupils. This preference of rural school pupils for this topic might be that farming is the mainstay occupation in the rural areas. It is expected that pupils in rural areas will have high level of interest to learn about such topic.

Pupils from both urban and rural schools selected similar and least appealing topics. Pupils seem to perceive these least mentioned science topics as perhaps, lacking their necessities of life for pupils. As already mentioned, apart from 'Ghosts and witches, and whether they may exist', all the least appealing topics or phenomena appear contextually unfamiliar to them and pupils might not recognise the necessity to learn about them. Television programmes about science, the environment and technology, which are fascinating and might bring these pupils closer to some of these topics, if they do exist, are scanty in Ghana. Even if these programmes do exist, pupils from rural schools will be at a disadvantage as compared to their counterparts in the urban settings. In a study devoted to gender issues and attitudes towards science, Murphy (1990) concluded that early childhood experience, such as exposure to the media and advertising play a vital role in shaping a child’s interest and self-image. Ghana Educational policy makers might take an important lesson from this area of learning, but at same time, avoid inequalities in access. This is because in practice many obstacles prevent children in rural areas from acquiring adequate grounding in science.

Urban and rural school pupils’ interests in science subjects

It is interesting to note a slightly rural dominance in the content and context of the science subjects (see figures 7-3 and 7-4). The average responses for pupils in rural schools were higher (overall mean = 2.92) than the interest expressed by pupils in urban schools (overall mean =2.88) for reasons already mentioned in section 7.4.3. One is likely to expect lower levels of interest in science courses among rural pupils, as compared to their urban counterparts. This is because the rural pupils are disadvantaged in terms of educational and financial resources. Some science education studies have indicated that pupils’ attitudes and aspirations in science are affected by their access to resources. Attitude (or interest) and achievement have been linked to access to resources (Webster and Fisher 2000; Barton 2001). There are fewer opportunities to school science in the rural settings, yet rural school pupils appeared to exhibit excitement about or interest in science programmes. This is contrary to the findings of Zuniga *et al.,* (2005). They revealed that lack of opportunity will rather lead pupils to dislike science even more. The finding in this study suggests that pupils perceived to be marginalized are likely to enjoy school science more when equitable educational opportunities are provided.

Significantly, agricultural science and botany gained rather high scores in favour of rural school pupils. Considering the fact that farming is the main occupation of the rural community in Ghana, makes this finding very realistic. It further demonstrates that rural pupils wanted to study science subjects that have relevance to their daily life activity.

On the other hand, an aspect of biology that featured prominently in pupils' responses, and which seemed to generate interest among all groups of pupils, especially girls and urban pupils was health science that focuses on health enhancement. The attraction of this branch of biology to the attention of most pupils probably was in its relevance to themselves.

Food production, health, sanitation, the combating and control of epidemics and diseases are among the challenges facing the developing countries in Africa, like Ghana. It will be expected that most pupils would show interest to learn the ways in which healthy body might be achieved and maintained perhaps, through means such as dieting, exercising, controlling epidemics, diseases and the spread of HIV/AIDS. They might also want to protect themselves against sexually transmitted diseases.

Health issues have become a matter of great concern for the urban population. Overcrowding of people in urban areas has become a common occurrence in Ghana. This puts excessive pressure on utilities that has led to, for example, shortage in the supply of potable water and inadequate places of convenience in some parts of urban settlements. Such situations in a way do adversely affect people's health. It appears urban pupils are aware of some of the health related issues emerging from over population. This might account for the high level of interest in health science among urban pupils.

Figures 7-3 and 7-4 show that urban and rural pupils were both interested in contextual approach to physics learning. It might be that this area of physics is less mathematical and more exciting. According to Sjøberg (2002c), physics (perhaps, the content area) which appears more mathematical is the most problematic for both pupils. This seems to be confirmed by all groups of pupils in this study. The finding also accords the suggestion put up by Anamuah-Mensah (1995). According to Anamuah-Mensah, a science subject, like biology perceived by pupils as being less mathematical appears easier to learn. Physics in content area is at fifth position on the urban pupils' list whiles it is at an eighth position for rural pupils. This is the situation when one considers only the way the subjects appear in the two figures but without referring to the mean values. One might conclude that rural pupils would have preferred other subjects to physics (content). This perhaps, could be due to the perception of relevance to their lives.

It seems both urban and rural pupils were less interested in chemistry (content and context), health science (health risk) and zoology. These areas of science appear less mathematical at their level and one would have expected all groups of pupils to have a higher interest in them. This is because mathematics has been identified as being problematic in science learning. This observation might indicate that one must go beyond the problem of mathematics to other factors that could militate against science learning. Some of these factors could be that the content and practice of science education have not been connected with pupils' interests and experiences. This may lead to a sense of its irrelevance to their lives as suggested by Rutherford and Ahlgren (1990).

7.6.4 Urban and rural school pupils' differences in topics of interests

The mean responses on some of the selected science topics of interest by urban and rural school pupils showed differences that are statistically significant. It appears there are no obvious patterns in these differences (see Appendix C). Categorising these differences into interest profiles for urban and rural pupils becomes quite challenging. I will consider few examples and give tentative explanations for those observations. Pupils from rural areas seemed to have higher levels of interest to learn about very high proportion of the science topics more than the urban pupils (24 out of 108 topics as against 10 for urban). There could be many reasons for this observation. Some of the possible reasons have already been indicated in this study. The rural school pupil is more disadvantaged than urban school pupil when it comes to access to education. Perhaps, it is due to low socio-economic status and educational background that are more likely to be associated with most parents of the rural pupils. Some of these parents are likely to view education as luxury, unimportant and unrewarding. A typical rural school pupil is likely to be denied of an access to education. However, it is likely that parents who have themselves experienced schooling will be better placed to bridge this perception gap (Peacock, 1995). It is not surprising that pupils in rural areas were interested in a lot more science topics than urban counterparts. This may mean that the interest to learn and study school science is likely to be higher for pupils in the rural areas when they are equally motivated.

For example, pupils in rural areas showed higher levels of interest than urban school pupils to learn about 'Organic and ecological farming without use of pesticides and artificial fertilizer'. It is also noteworthy to see that the high level of interest indicated by rural school pupils appears connected with their interest shown in 'How plants grow and reproduce'. The expression of high level of interest for these two topics by this group of pupils becomes obvious since farming is the main occupation of rural areas of Ghana. Most pupils in the rural areas might perceive these topics to have some relevance in their daily life activity. This group of pupils are closer to nature and are likely to have high dispositions towards nature and environment with regard to the use of pesticide and artificial fertilizer. This might have featured strongly to influence their interests in those topics. The responses by pupils in the rural areas to those topics reinforce the impression that pupils in developing countries do indicate some remarkable high interest in topics that relate to the environment. This is found in the SAS-study (Sjøberg, 2000b).

There are some other topics that I find more popular with pupils in rural areas. The topics appear to have some personal and social relevance for the rural community that need commenting on. A list of science topics such as: 'Epidemics and diseases causing large losses of life', 'Medicinal use of plants', 'The possible radiation dangers of mobile phones and computers' and 'How different sorts of food are produced, conserved and stored'. The challenges of underdevelopment are likely to affect the rural community more than that of the urban community since most of the rural communities have long been marginalized. One might expect that children in these two different areas would get very different life experiences, hopes and aspirations. It might be expected that most rural pupils may indicate an eagerness to learn about the topics that relate to these challenges more than their urban counterparts. Strikingly, as rural school pupils expressed high interest in 'How mobile phones can send and receive messages' which tops their ten most popular science topics, they also tended to be interested in knowing about the negative effect of the use of mobile phones on human health. This is seen as they indicated higher level of interest than urban school pupils to learn about the possible radiation dangers of mobile phones and computers. Many of the remote rural communities in Ghana do not have adequate access to health facilities, such as hospitals and clinics. The majority of the rural people tend to depend mostly on the herbal treatment of a lot of diseases. Many of them are likely to recognise the importance of medicinal plants in their communities. A typical rural pupil is more likely to be interested in the medicinal use of plants. Post harvest loss is also one of the challenges facing adequate food production that confront many of the developing countries.

A search for ways of producing food, preserving and storing becomes one of the important concerns for the developing countries. The challenges of food production affect more of the rural communities where farming is their main occupation. Such challenges might have influenced the rural pupils' interests in how different food items are produced, preserved and stored. These findings shed light on the relative importance of the geographical background aspect when it comes to the discussion of the science curriculum.

On the other hand, 10 out of 108 science topics showed statistically significant difference in favour of urban pupils. As pointed out earlier in this section, there is no clear pattern in the differences in the interest profiles between the urban and rural pupils' science topics. However, three science topics that went for urban pupils which showed statistically significant differences appear to be most important challenges facing the urban society in Ghana. These challenges are related to health and environmental issues. Consequently, the topics on 'Sexually transmitted diseases and how to protect against them', 'How alcohol and tobacco might affect the body' and 'How technology helps us to handle waste, garbage and sewage' are commented on. A possible explanation for urban pupils' higher levels of interest for these topics could be that due to urbanisation, awareness has been created in most urban pupils. Facilities in urban areas such as internet, television programmes and to less extent, the print media might have facilitated such awareness. Through the electronic and print media, discussions of topical issues related to health and environment have become a frequent occurrence in Ghana. Sexually transmitted diseases, alcohol and tobacco related diseases and management and effect of wastes, garbage and sewage are often discussed on electronic media. It may be expected that due to awareness created among the urban population in general, the urban school pupils when given opportunity, might show higher levels of interest than rural school pupils to learn about these topics as seen in their responses.

It is noteworthy to recognize that the pattern that emerges throughout the discussion of pupils' interest profiles relating some science topics is an indication that equity concerns in science curriculum should focus more on the gender differences and less on other aspects, such as geographical background or social class. This conclusion is based only on the interest in science topics aside the school environment and other educational opportunities.

7.6.5 Ghanaian pupils' topics of interest as compared to that of pupils from other countries

The examples illustrated in figure 7-5 revealed different interest profiles of the respondents across countries in learning about the science topics that are listed in question ACE. The interest of the respondents in learning about the topics appeared to relate to the level of development in a country. In general pupils from developing countries were found to be far more interested than pupils from more economically developed countries. The gender differences in developing countries were less pronounced as compared to other developed countries, but to some varying degree. In the high HDI countries, the gender differences were more pronounced, with girls' interests more related to biology topics such as how the human body grows and matures; and what to eat to keep healthy and fit. Boys were more attracted to the physical science topic, like how computers work. Evidence from the data corroborates other findings where girls and boys preferred biological and physical science topics respectively (see Clark 1972; McGuffin, 1973; Smithers and Hill, 1987).

The result appears to support the comment that the higher the level of development in a country (reference to HDI value for a country), the lower interest pupils express in learning about school science and technology related topics (Sjøberg, 2000b, 2002a; Sjøberg and Schreiner, 2005b). The empirical finding in this study can add to the information needed to guide the current discussions on how curriculum and instruction in science and technology can be designed in order to appeal to different groups of learners. The strategy of finding out what pupils would want to learn in science demonstrates further, an approach that can be adopted to motivate pupils to learn science.

Conclusion

This survey showed high interest in science and technology studies among Ghanaian pupils, especially the JSS 3 pupils in the sample area. The gender variations in areas of science and technology studies were not many. Both genders rather showed similar interests in many aspects of science and technology. However, biological sciences continued to attract the interest of more girls while physical sciences and practical aspects of science were the interest areas of boys. For urban and rural schools pupils, there was no clear pattern in their interests in science and technology related topics.

However, all groups showed similarities in the ten top most and the ten least appealing science and technology related topics. They appeared inclined to sciences in context areas, especially in the contexts of the traditional sciences, health science and in the modern technology education. If their interests in science and technology or their positive attitudes towards science and technology could be a measure for recruitment to science and technology studies then based on the empirical evidence from this study, there could be no likelihood of a fall in recruitment to science and technology studies overtime. However, if there could be future recruitment challenges to science and technology, then one might explain and address it based on the lack of expansion in educational facilities or opportunities to accommodate the larger proportion of pupils who might show enthusiasm for science and technology studies.

Most pupils did not consider some topics interesting to learn in school science. Perhaps, those topics were of no practical personal and societal relevance. It could also mean that some of those topics appeared non-scientific or unfamiliar processes in science to them. Some of these topics that might be perceived as non-scientific and irrelevant are myths about ghosts and witches. The others are the likely unfamiliar topics such as black holes, supernovas and other spectacular objects in outer space.

In this chapter, I have provided some topics which Ghanaian JSS pupils would want to learn about in science that might be considered in the design of the science curriculum. Some of these topics of interests have been compared with those of pupils from other countries. I will now elicit and also reflect on the views pupils might hold about environmental challenge issues as they relate to school science. The next chapter provides such information through the research question: What views do these children hold about environmental challenges?

8. THE CHILDREN'S VIEWS ABOUT ENVIRONMENTAL CHALLENGES

8.1 Introduction

It is essential for research in environmental education to identify students' conceptions and understandings about the environment (Payne, 1998). Science education has a key role in preparing young people to cope with the emergence of environmental challenges. When pupils are well exposed to school science, they are likely to make informed decisions and actions on environmental challenges (NRC, 1996).

This research question (what views do children hold about environmental challenges?) focuses on how youth would want to associate with some environmental matters regarding science learning. As mentioned earlier, science educators need to develop knowledge and awareness of what pupils are exposed to, in the face of our effort to equip pupils to meet the environmental challenges as they relate to school science. This was made possible in this study through the analysis of responses by pupils to the list of items that has the theme ''Me and the environmental challenges'' (D-items). This theme has 18 statements on some environmental issues and pupils were invited to indicate the extent to which they agree with the statements on a 4-point Likert-type scale which goes from 'Disagree' to 'Agree'. The theme assesses pupils' attitudes and their sense of responsibility on environmental issues.

8.2 Results

The overall mean values of the variables were not determined for the groups since all the negative statements were not reversed. For example, D3 (*Environmental problems are exaggerated*), D8 (*People worry too much about environmental problems*) and D13 (*Environmental problems should be left to the* *experts*) were not reversed. The overall mean value becomes meaningless in this circumstance and may not give a clear picture of pupils' general view about environmental challenge issues. Only the D1 statement was reversed. This made the interpretation of the other negative statements easier. However the mean scores for each variable were calculated for boys and girls separately as well as for urban and rural school pupils. These are presented as graphs in figure 8-1 and figure 8-2; and also in figure 8-3 and figure 8-4. In these diagrams, the highest mean is at the top and least is at the bottom.

8.2.1 Boys' and girls' views about environmental challenges

When mean scores were considered for each statement, there were few of them that both boys and girls showed some levels of disagreement with mean values less than 2.5. As already stated, a mean score of 2.5 represents a neutral position and for these statements, it indicates neither agreement nor disagreement with a statement.

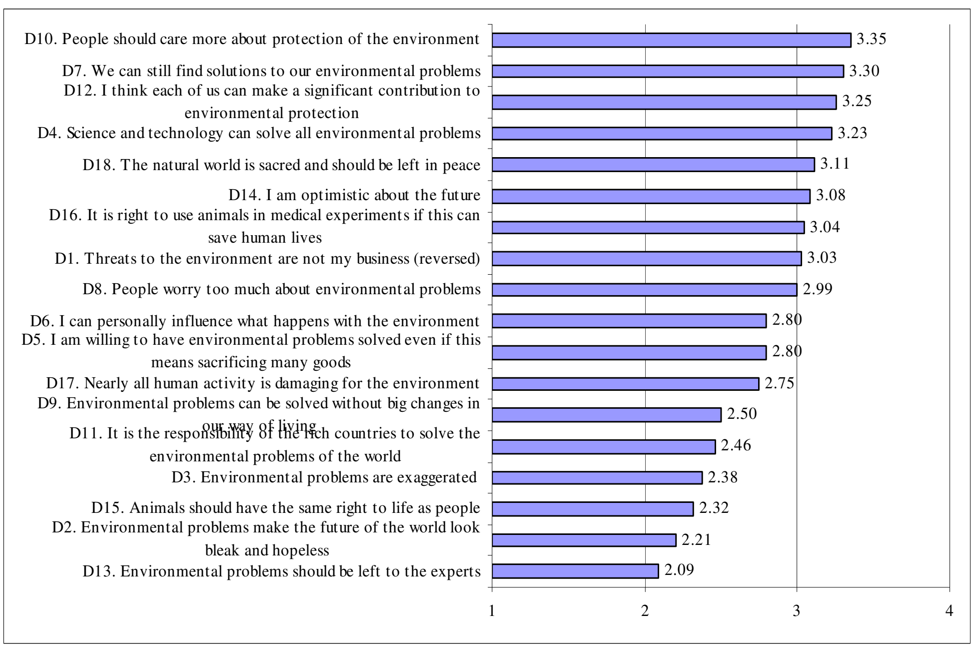

Figure 8-1. Boys' responses on attitude towards the environmental concerns. Highest mean value is at the top and least at the bottom.

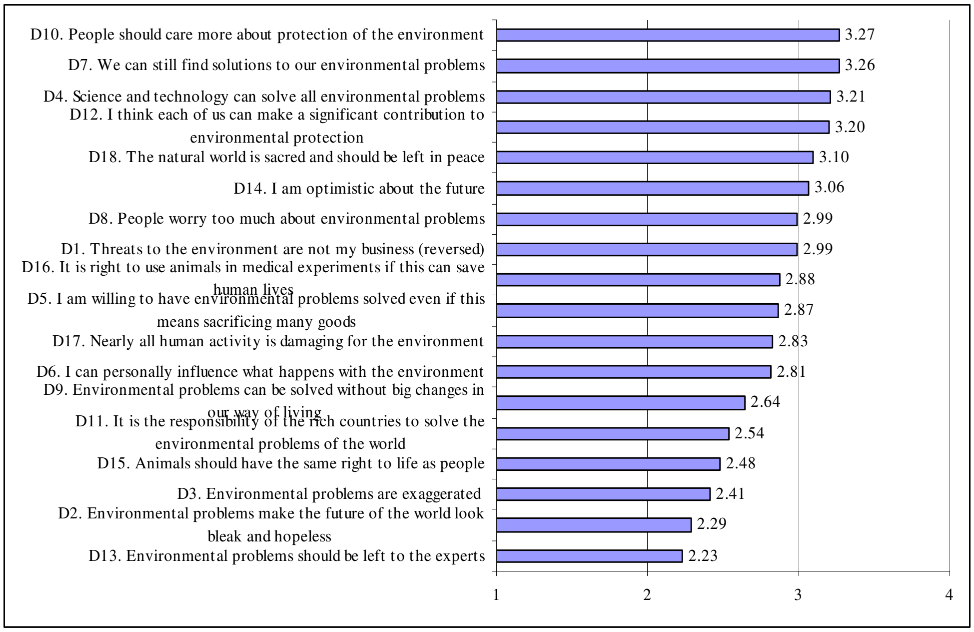

Figure 8-2. Girls' responses on attitude towards the environmental concerns. Highest mean value is at the top and least at the bottom.

From the two diagrams (Figure 8-1 and Figure 8-2) boys and girls were both in agreement with all the statements except: “Animals should have the same right to life as people”, “Environmental problems are exaggerated”, “Environmental problems make the future of the world look bleak and hopeless”, “Environmental problems should be left to experts”. Most Ghanaian boys and girls in this study seemed to strongly agree that we should care more about the protection of the environment, and that the solution to our environmental problems can be found. They appeared to believe that an individual contribution to environmental protection is significant. Also, they did not agree or think that environmental problems should be left to the environmental experts as can be seen from the low agreement to the statement that the environmental problems should be left to the experts.

Although, they strongly agreed that science and technology can solve all environmental problems, they also appeared to think that the natural world is sacred and should be left in peace. However, there was a general view that the use of animals in medical experiments to save human lives is in the right direction. Considering the general views expressed about the environment, it appeared Ghanaian pupils are optimistic about the global future.

8.2.2 Urban and rural pupils' views about environmental challenges

Referring to figure 8-3 and figure 8-4, generally, there was some similarity in pattern of agreement with statements. However, to what extent they did agree or disagree with a statement varied in levels. The responses indicated a mean range of 3.47 to 2.14 for urban and 3.22 to 2.18 for rural.

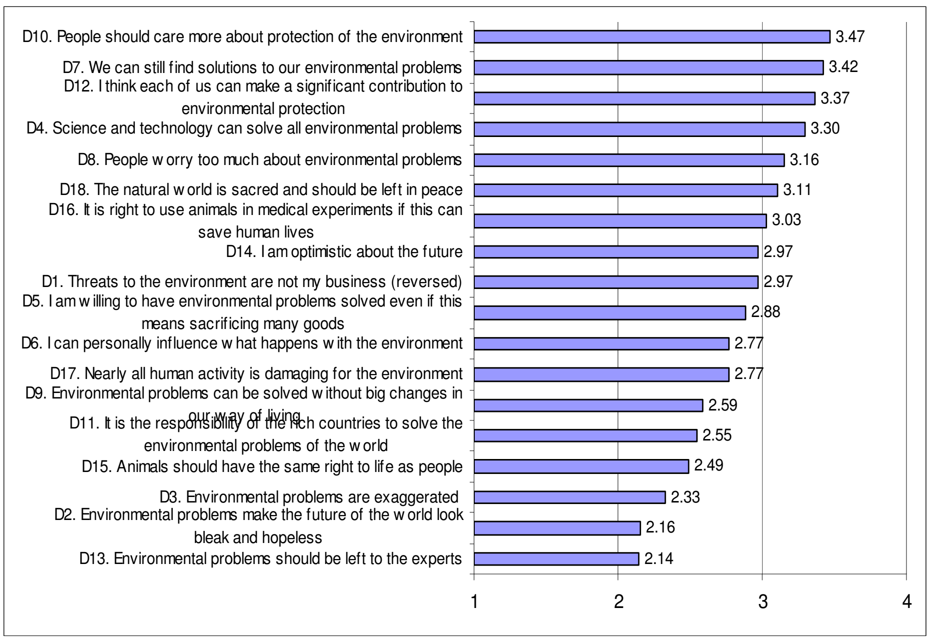

Figure 8-3. Urban pupils' responses on attitude towards the environmental concerns. Highest mean value is at the top and least at the bottom.

It is noticeable in Figure 8-3 that urban school pupils tended to believe in the involvement of everybody in environmental protection as they strongly agreed that people should care more about the protection of the environment. Perhaps, through individual involvement, they can make significant contribution to environmental protection. They agreed strongly that threats to the environment are each and everyone's business. The sense of responsibility to the environment was further confirmed by the urban pupils' willingness to get personally involved in protecting the environment even if it will cause them to sacrifice their goods.

Though, the urban school pupils tended to agree that the natural world is sacred and should be left in peace, they also believed that it is right to use animals in medical experiments if this can save human lives. According to the pupils, animals should not have the same right to life as people.

They disagreed that environmental problems are exaggerated and did not also agree that environmental problems make the future of the world look bleak and hopeless rather they were optimistic about the global future. Although they agreed that science and technology can be "solver" of all environmental problems, they expressed reservation about leaving environmental problems to the experts.

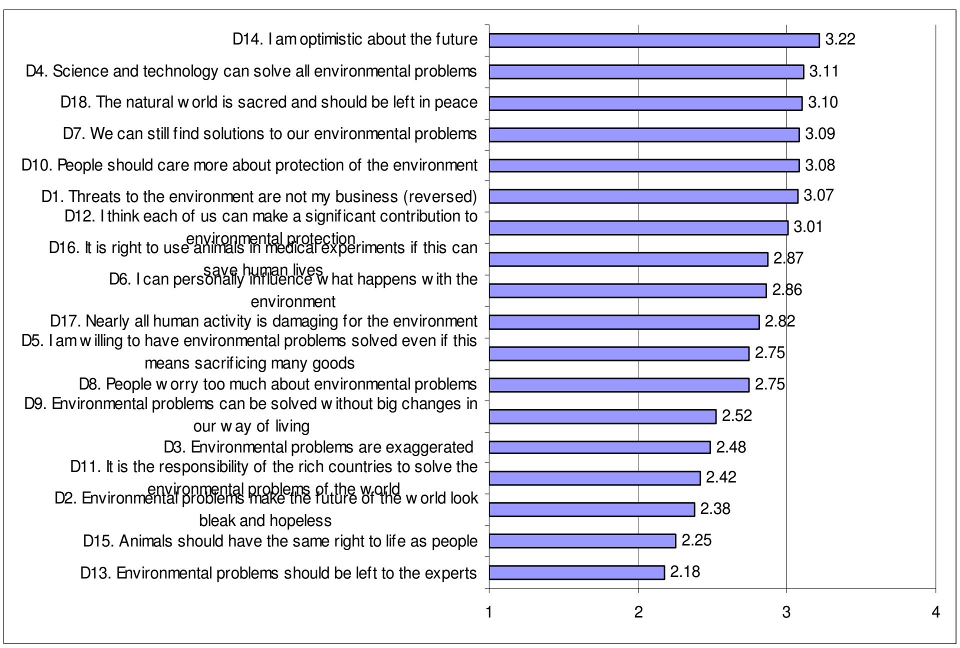

Figure 8-4. Rural pupils' responses on attitude towards the environmental concerns. Highest mean value is at the top and least at the bottom.

It is also evident in figure 8-4 that the views expressed by rural school pupils about the environment appeared to be similar to those expressed by urban school pupils though, there seem to be some variations in levels of agreement. The rural school pupils were very optimistic about the global future. They also believed people can still find solutions to our environmental problems through science and technology, but they disagreed with the statement that environmental problems make the future of the world look bleak and hopeless.

They tended to agree that the natural world is sacred and should be left in peace and people should care more about protection of the environment. To them, the threat to the environment must be seen as everybody's business and also, they believed that each of us can make a significant contribution to the environmental protection. Perhaps, they personally wanted to involve in the environmental protection, and did not agree that it is the responsibility of the rich countries to solve the environmental problems of the world. This is further seen in their responses, showing that they did not agree that environmental problems should be left to the experts.

Most Ghanaian rural school pupils disagreed with the statement that animals should have the same right to life as people, but they agreed that it is right to use animals in medical experiments if this can save human lives.

8.2.3 Ghanaian pupils' views about the environment as compared to that of pupils from other countries

Figure 8-5 presents four examples of views Ghanaian pupils hold about environmental challenges compared with other countries. The statement *People should care more about protection of the environment* attracted the attention of all pupils in each country. The mean scores were far beyond the neutral response value of 2.5 for the developing countries however, it was less beyond for the developed countries. These values were all high on the 4-point Likert-type scale. The empirical data suggest that pupils in all countries strongly agreed with this statement. Apart from Ghana and Lesotho, girls were more concerned about the environment than boys in all countries.

In all the countries, the majority of pupils were very optimistic about the environment. They strongly agreed that we can still find solutions to our environmental problems. Girls showed more optimism than boys. In Ghana, Uganda, Lesotho and few of the high HDI countries, like Denmark, Norway, England, Trinidad and Tobago, it appeared their concerns were rather gender neutral. On the average, pupils from some of the medium HDI countries (Czech Republic and Latvia) expressed less optimism.

While most of the pupils in the less developed countries believed strongly that science and technology can solve all environmental problems, pupils in the developed countries (including some of the medium HDI countries) differed in their views about science and technology in meeting all the environmental challenges. While the majority of boys in the less developed countries were more convinced about this role of science and technology regarding the environment, both genders in Ghana had similar view. In many of the developed countries, pupils disagreed with this statement. Girls in these countries were much more sceptical than boys; and the Japanese pupils were the most sceptical to science and technology, especially the girls.

The majority of pupils agreed with the statement that the natural world is sacred and should be left in peace, but more girls than boys believed that the world is too important to be changed. In Ghana, India and Trinidad and Tobago, both genders were of the same belief. However, in most Asian countries and other parts of Europe, including Turkey and Greece, the sacredness of the world was much more important to them.

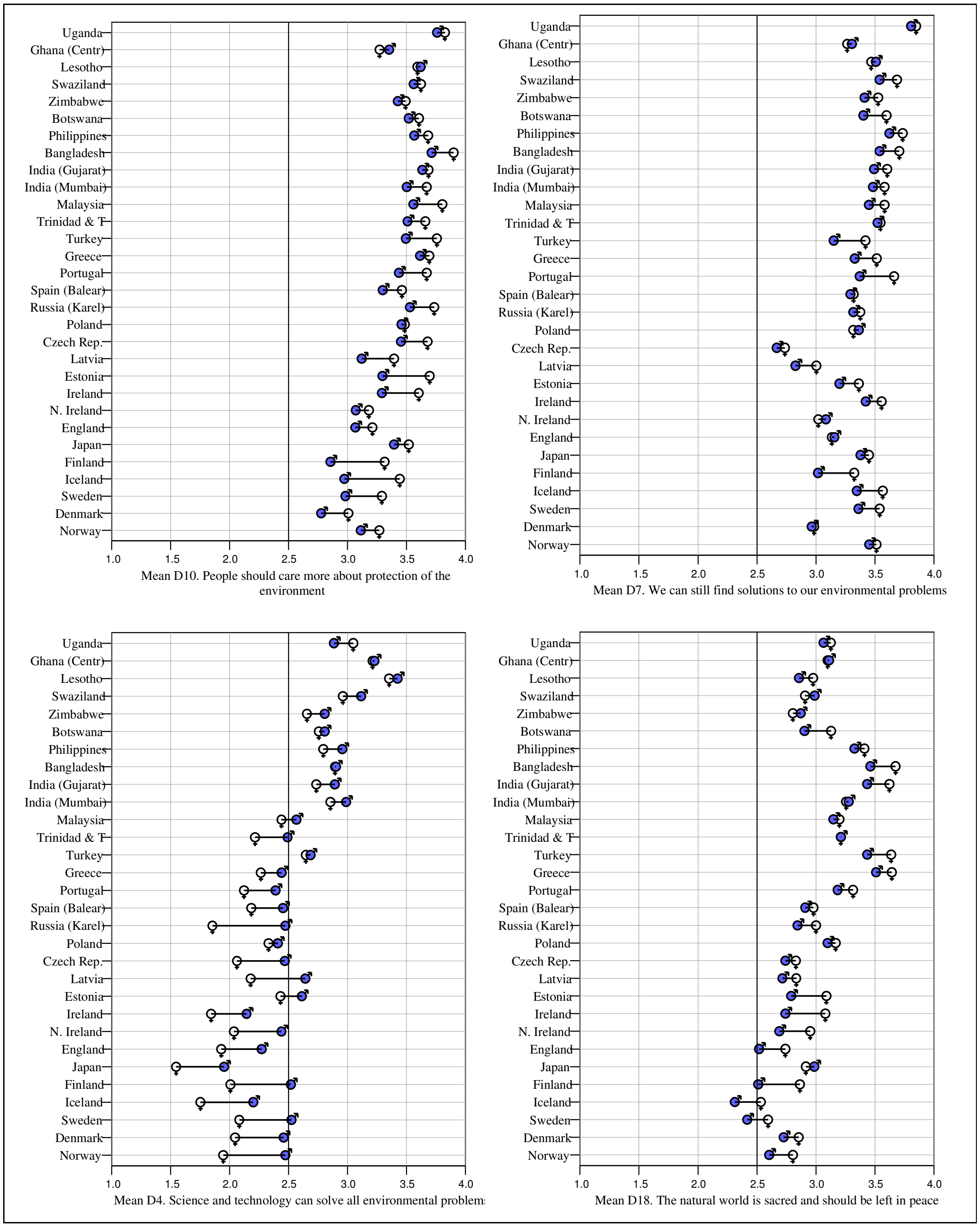

Figure 8-5 Illustrative examples of the pupils' views about environmental challenges across countries. See caption of figure 7-5 for diagram explanations.

8.3 Discussion

8.3.1 Boys' and girls' views about environmental challenges

As indicated in the two diagrams (figure 8-1 and figure 8-2), both boys and girls would want to practice responsible environmental behaviour and appeared to associate themselves with the statement that people need to care more about the protection of the environment. They also had a strong belief that threats to the environment should be the concern of everyone. They subscribed to useful environmental actions by individuals thereby indicating that, nearly all human activity damage the environment. They seemed to show optimism about the environment and strongly agreed that solutions to the environmental problems can be found and hence pupils appeared to disagree that environmental problems make the future of the world look bleak and hopeless. This finding is in line with some preliminary results from the analyses of the Norwegian ROSE data, which involved 1200 fifteen-year-old Norwegian pupils on how they relate to environmental challenges (see Schreiner and Sjøberg, 2003). Schreiner and Sjøberg confirmed the pupils' general concern about the environment. However, Ghanaian pupils were also interested to learn environmental education as school science subject (see section 7.4.1).

Most Ghanaian pupils disagreed that environmental problems are exaggerated. In line with this, they are likely to be motivated for solving environmental problems. The motivation to solve environmental problems is also seen in the pupils agreeing with the statement that individuals can make a significant contribution to environmental protection. They were also in disagreement with the statements that it is the responsibility of the rich countries to solve the environmental problems of the world and also to leave environmental problems to the experts. This agrees with the findings of a study involving elementary school children of the United Kingdom aged between 11and 13 years. All the children assert the individual responsibility for the environment and not others or the government (Bonnet and Williams, 1998). However, in this study, Ghanaian pupils in addition expressed positive views about the role of science and technology in solving environmental problems. This is confirmed by pupils' strong agreement with a statement that science and technology can solve all environmental problems. It is therefore not unexpected that pupils expressed a high level of interest in technology education.

It might seem that boys and girls in Ghana would want to be active participants in keeping the balance between quality of life and the environment. Their responses indicated a willingness to have environmental problems solved even if this means sacrificing many goods. They also strongly agreed that the natural world is sacred and should be left in peace. It seems Ghanaian pupils perceive human beings to be much more important than animals, as they disagreed that animals should have the same right to life as people. Perhaps, this observation is consistent with pupils' responses that indicated a strong agreement with a statement that it is right to use animals in medical experiments if this can save human lives.

8.3.2 Urban and rural pupils' views about environmental challenges

A similar pattern was found when we turn to figure 8-3 and figure 8-4. The overall picture was that the concerns expressed about environmental issues were the same for gender and urban/rural pupils.

Irrespective of the gender or geographical location, the majority of pupils in the sample shared the same sentiments towards environmental protection issues. For example, most of the respondents were of a strong opinion that science and technology can solve all environmental problems and also, the natural world is sacred and should be left in peace. They contended that the solutions to our environmental problems could still be found. Despite their optimisms about the future of the globe, they also appeared to agree that people should care more about the protection of the environment. Their positive attitudes towards environmental challenge issues appeared to be consistent with responses, which showed that they strongly agreed that the threats to the environment are everyone else business. They also believed that each of us can make a significant contribution to environmental protection.

The views of the Ghanaian pupils in the sample about the issues of environmental challenges suggest that such issues cut across cultures (see Szagum and Pavlov, 1995) and hence, the environmental matters are a global concern for the young learners. This is seen in the light of the fact that many pupils from different cultures continue to show optimisms about the future of the globe and believe in their abilities to help in solving environmental problems through variety of actions (see Schreiner and Sjøberg, 2003; Bonnet and Williams, 1998). However, Ghanaian pupils in addition would want to learn some aspects of environmental matters at school science and probably through learning, they may develop attitudes and skills conducive to environmental preservation. This appears to place Ghanaian pupils in a better position in their attempts to help in solving the current environmental problem, which has become one of the major challenges confronting many developing countries.

It has been suggested by Huang and Yore (2003) that *prior knowledge* as well as values, beliefs, attitudes, concerns and emotional dispositions of learners might influence their understandings about and capabilities to act towards the environment. It is my conviction that teaching needs to be based on pupils' *knowledge*, attitudes and conceptions of the environmental protection issues.

Ghanaian pupils in this sample seemed to believe that it is right to use animals in medical experiments if this can save human lives. One may interpret this finding in many ways; pupils in the sample are probably placing matters of health high on the issues of challenges of life or it might be that the Ghanaian culture does not appear to recognize animals to have some kinds of right.

8.3.3 Ghanaian pupils' views about the environment as compared to that of pupils from other countries

The empirical data as seen in figure 8-5 appear to suggest that majority of pupils in all the countries, irrespective of the gender or level of development, shared the same sentiments towards environmental protection issues. However, contrary to the respondents in the high HDI countries, those from the low HDI countries were of stronger beliefs that science and technology can solve all environmental problems. Also, all groups of pupils were of the opinion that the natural world is sacred and should be left in peace. It becomes apparent that the positive attitudes of pupils towards environmental challenge issues cut across all countries, but of varying degree (see Szagum and Pavlov, 1995) and that the environmental matters appear to be one of the most pressing topical socio-scientific issues of the global world. The fact is that many pupils from different cultures continue to show concerns for the future of the globe (see Schreiner and Sjøberg, 2003; Bonnet and Williams, 1998).

The pattern of the responses to the issue of the natural world as sacred can be interpreted in a number of ways. One is likely to interpret the response to mean that in some countries where it appears there is strong adherence to religious and superstitious beliefs, the majority of pupils were in stronger agreements with the statement that the natural world is sacred and should be left in peace. Perhaps, these pupils tend to think that sacredness is associated with holiness, religion or connected with God in a special way and might have influenced their opinions. But the question is: can religion instead of science be used to influence pupils' attitudes towards the environmental challenges facing many countries, especially the less developed countries? I do not intend to answer this important question; however, it may be an interesting question for further research.

Conclusion

The majority of pupils in the sample, irrespective of the gender or geographical location, shared the same sentiments towards environmental protection issues.

For example, the respondents agreed that science and technology can solve all environmental problems; the natural world is sacred and should be left in peace. They agreed that the solutions to our environmental problems can still be found. Despite their optimisms about the future of the globe, they also appeared to maintain that people should care more about the protection of the environment. Their positive attitudes towards environmental challenges could be seen in their strong agreement levels shown with the statement that the threats to the environment are everyone else business. They also believed that each of us can make a significant contribution to environmental protection.

Ghanaian pupils perceived human beings to be much more important than animals, as they disagree that animals should have the same right to life as people. They further agreed strongly that it is right to use animals in medical experiments if this can save human lives. An interesting aspect of Ghanaian pupils' concerns for environmental protection issues is that they also showed enthusiasm for environmental education studies perhaps, in order to gain knowledge in environmental protection issues.

I have sought the views the Ghanaian JSS pupils hold about environmental challenge issues, and made some comparisons with pupils in different countries. In chapter 9 I will look at how pupils in this study perceive their school science in general. This will be made possible through the third research question: How do these children relate to school science?

9. THE CHILDREN'S RELATIONSHIPS WITH SCHOOL SCIENCE

9.1 Introduction

This chapter touches on the pupils' perception of their science classes, including what they get out of science at school and the necessity of science education. The responses provide an opportunity to describe what pupils in Ghana actually perceive about their science classes. A subset of the questionnaire items on ‘‘My science classes’’ (F-items) was used to indicate the extent of pupils' attitudes as they relate to school science, and has 16 statements, each with a 4-point Likert-type scale from ‘Disagree’ to ‘Agree’. Pupils were asked to respond to these questionnaire items which sought to explore aspects of attitudes towards science and science education. The overall pattern of responses by gender are presented in figures 9-1 and 9-2 and the data relating to urban and rural school pupils are also represented in figures 9-3 and 9-4. The overall mean and mean scores for each variable are also considered for boys and girls as well as the urban and rural school pupils. The item F 01 (School science is a difficult subject) was inverted due to negative wording.

9.2 Results

9.2.1 Boys' and girls' relationships with school science

Most pupils showed high enthusiasm for school science as the overall average scores for boys and girls were 3.36 and 3.29 respectively, which were far on the “agree” side of the neutral response value of 2.5. However, boys tended to be more passionate about school science than girls as they indicated a high degree of agreement with a list of 16 statements about their science classes. The responses to these statements are presented in the diagrams of figures 9-1 and 9-2. It is evident from their responses as given in the figures below that both genders seemed to feel more positive about their science classes (mean scores ranged from 3.60 to 2.74 for boys and 3.56 to 2.63 for girls). It appeared both boys and girls perceive science to be fascinating, important and probably relevant. However, the levels of excitement, importance and relevance pupils hold for their science classes as indicated in their responses emerged to vary with the extent to which they agreed with those assertions they made about school science.

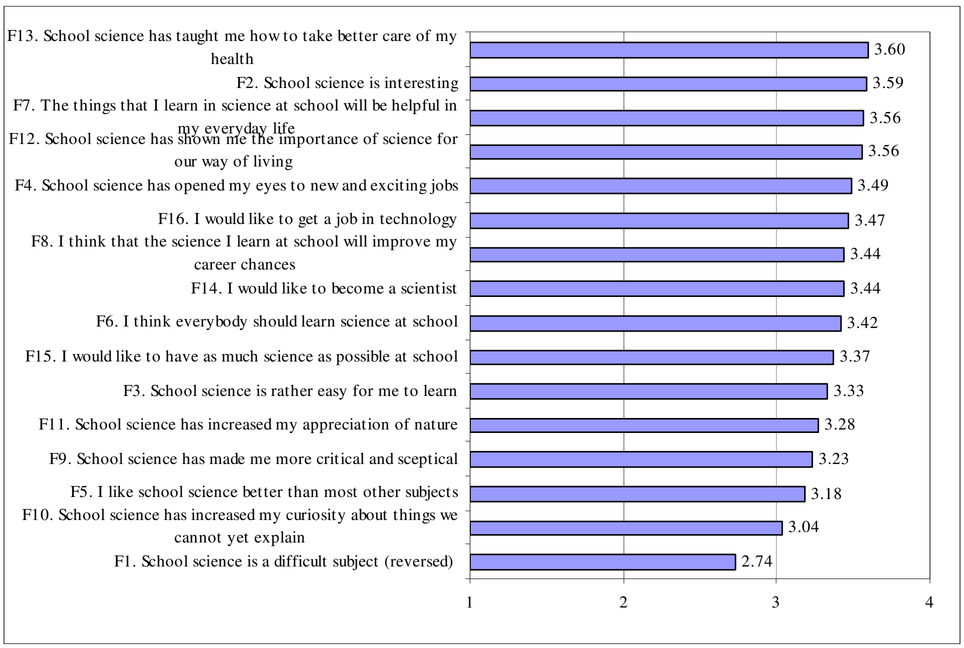

Figure 9-1. Boys' perceptions of and attitudes towards their school science. Highest mean value is at the top and least at the bottom.

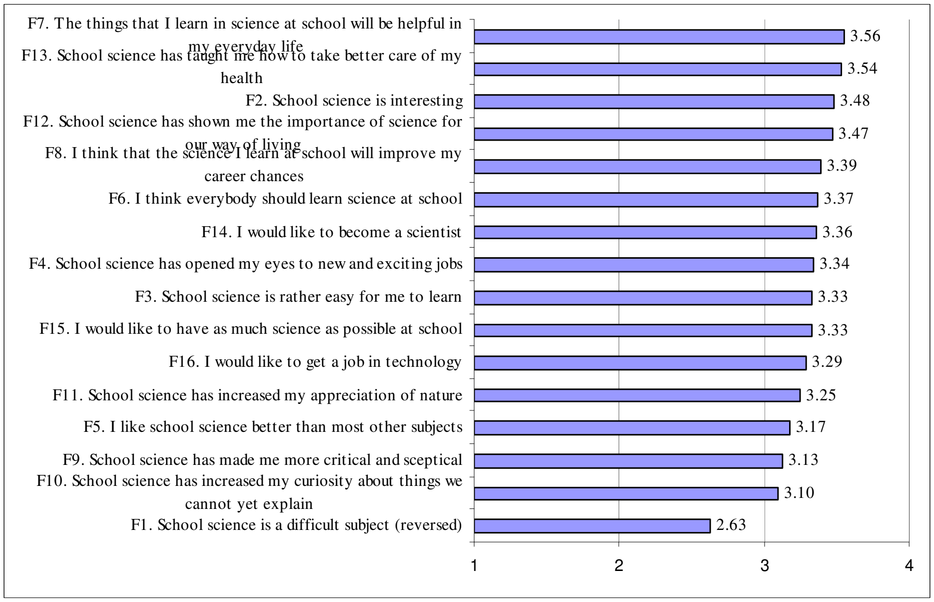

Figure 9-2. Girls' perceptions of and attitudes towards their school science. Highest mean value is at the top and least at the bottom.

9.2.2 Gender differences

Statistically significant differences were not many and also not large, which are indicative of both groups of pupils having similar experiences in some aspects of science.

Only five out of 16 items, that are some characteristics of school science, showed statistically significant differences by gender ($p<0.05$). The differences that emerged from responses to the items from boys and girls were all in favour of girls. The differences in their responses are given in the Appendix F. Specifically, girls agreed more than boys with the statements that school science is interesting but difficult as a subject, the things that they learn in science at school will be helpful in their everyday lives and that school science has taught them how to take better care of their health. Girls also agreed more than boys that school science will improve their career chances.

9.2.3 Urban and rural pupils' relationships with school science

The figures 9-3 and 9-4 provide the distribution of pupils' attitudes towards their science classes based on mean values and separated by urban and rural pupils. In the figures, the highest mean is at the top and decreases to the least value at the bottom. The data reveal that both urban and rural pupils had very strong positive attitudes towards science, with the exception of the statement 'School science is a difficult subject'. The mean values ranged from 3.65 to 2.78 for urban pupils and 3.50 to 2.55 for rural pupils. The urban and rural pupils' interest profiles regarding their interests in the science-related topics that are listed in the questionnaire subsets ACE tended to show a relationship with the scores that emerged from the analysis of the questionnaire subset F about their science classes. As both groups went for similar appealing and unappealing science topics, they also had similar attitudes towards science. However, there were variations in the agreement levels between the urban and rural pupils.

Most of the urban pupils felt more positive than rural school pupils towards their science classes. However, both groups of pupils appeared to perceive that school science has some level of difficulty as the overall mean values for this aspect of science classes were relatively close to the neutral response value. This is marked for rural pupils. The general picture that emerged from the analysis of pupils' responses on attitudes towards school science was that both the urban and rural school pupils seemed to consider or prefer school science to be mostly a personal relevant subject. Perhaps, this influenced them to agree strongly that everybody should learn science at school.

A clear difference between the groups' attitudes towards their school science was found regarding levels of interest towards science classes. Pupils from urban schools were more positive in their interests towards school science (mean value of 3.65) than rural pupils (mean value of 3.36).

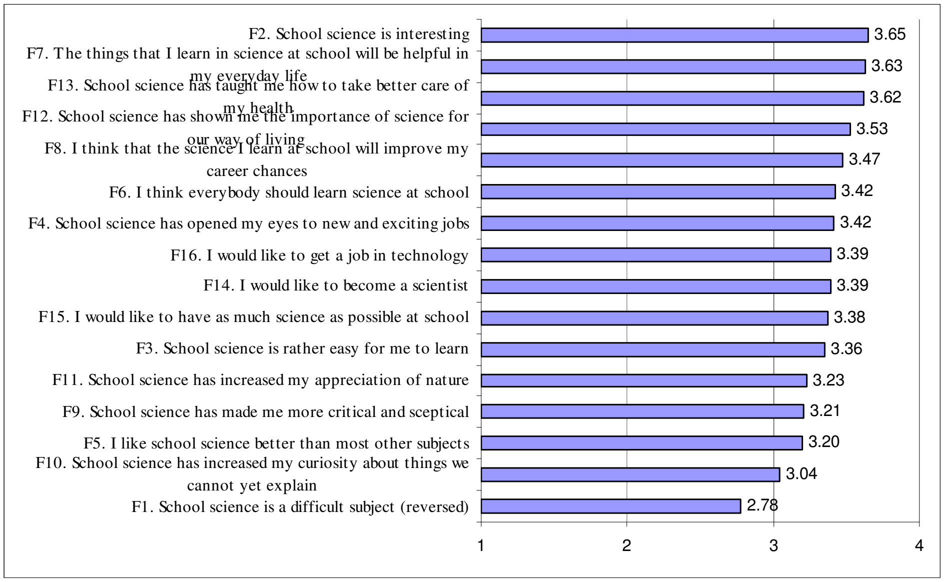

Figure 9-3. Urban pupils' perceptions of and attitudes towards their school science. Highest mean value is at the top and least at the bottom.

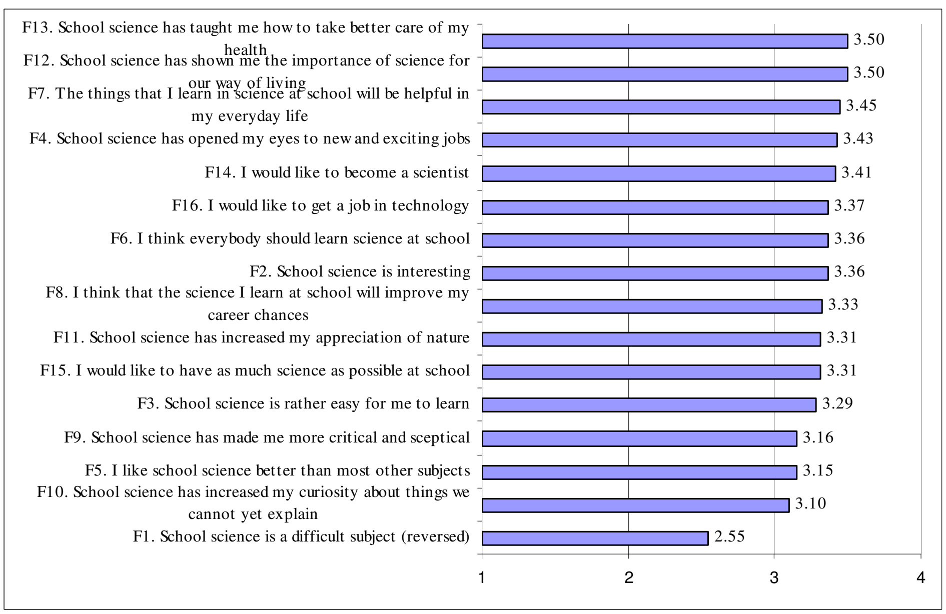

Figure 9-4. Rural pupils' perceptions of and attitudes towards their school science. Highest mean value is at the top and least at the bottom.

9.2.4 Urban and rural pupils' differences

There were few differences among urban and rural school pupils' perceptions of their science classes when agreement levels were considered. The majority of pupils in urban schools than rural schools agreed that school science is interesting (mean value of 3.65 as compared to mean value of 3.36 for rural pupils). However, the rural school children recorded highest agreement level with the statement 'School science has taught me how to take better care of my health' (mean value of 3.50). This is less than the mean value recorded for the same item with the urban pupils (mean value of 3.62). This ranks third on the urban pupils' agreement scale.

9.2.5 Ghanaian pupils' attitudes towards school science as compared to that of pupils from other countries

It is noticeable in figure 9-5 that there were large differences cross countries when the responses to the statements concerning school science were compared. Comparing the responses to the item *school science is interesting* across cultures showed that on the average, the interest scores for all countries were on the "agreeing" side of the neutral value of 2.5. In the developed countries (high HDI countries), the interest was lower than that of the less developed countries. Also the result indicated that the youth from the less developed countries were far more positive towards learning school science. However, the average scores showed that the young people in the developed countries also appeared to have somewhat interest in school science.

The majority of the youth in all countries in this study agreed that school science is relatively interesting. Most of them from the developed societies, especially the girls, disagreed with the statement *I like school science better than most other subjects*. In many of the developed countries, school science appeared less popular than other subjects, and in almost all the countries, girls seemed to dislike school science. In Ghana, however, both genders equally liked school science more than most other school subjects.

The mean scores in the developed countries showed a very low interest in becoming scientists. In all the countries, girls appeared somewhat hesitant, but were even more negative about becoming scientists than the boys in the high HDI countries. In Japan, however, the difference was much more pronounced than in all countries, with girls in Japan totally against the idea of becoming scientists.

In the developing countries, pupils agreed strongly that the things they learn in science at school will be helpful in an everyday life, but views on this between genders did not follow a clear pattern except in the medium HDI countries. In the medium HDI countries, girls more than boys agreed on the help school science can offer them in an everyday life. In Denmark, both genders in particular were more in doubt.

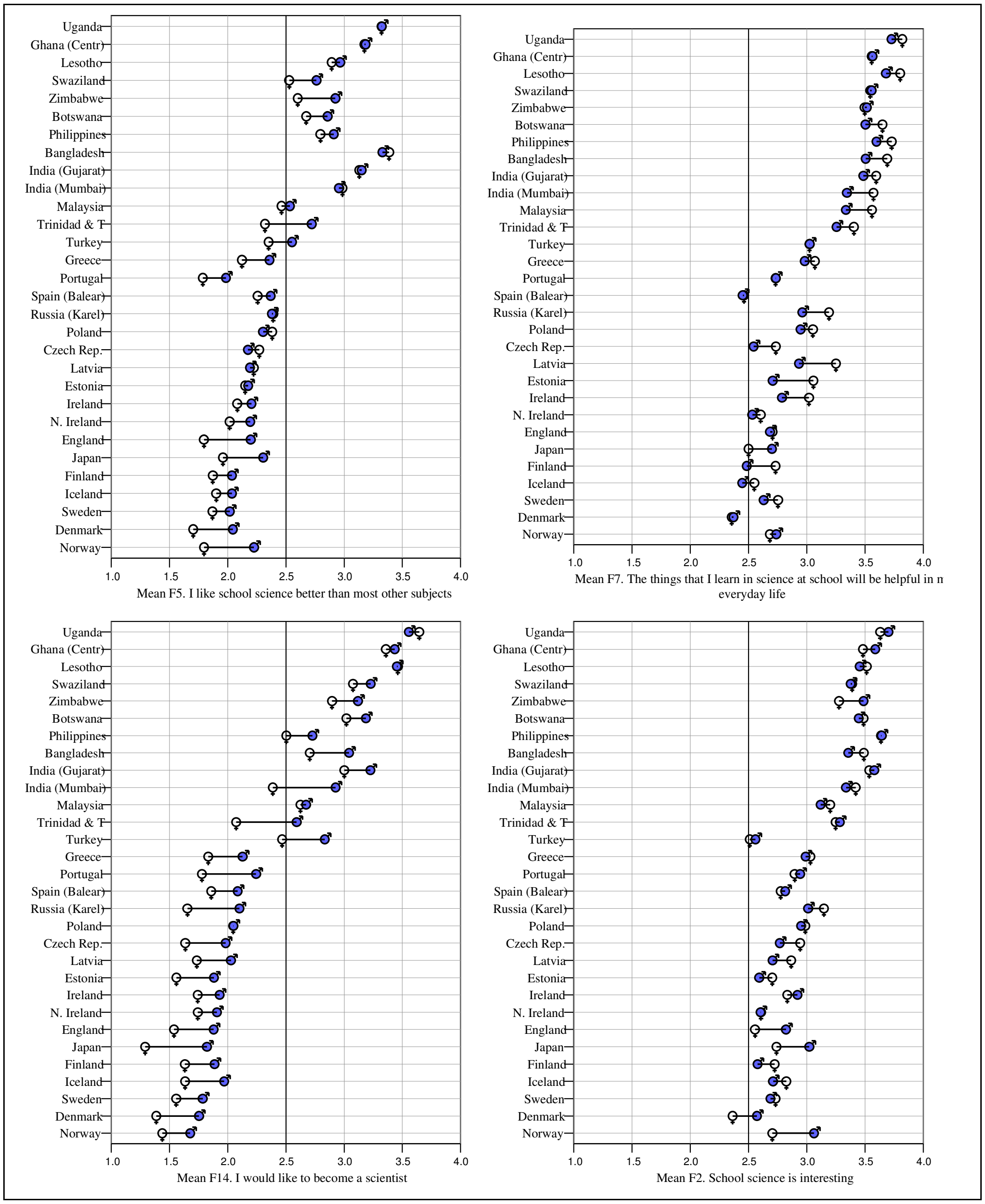

Figure 9-5. Illustrative examples of the pupils' attitudes towards school science across countries. See caption of figure 7-5 for diagram explanations.

9.3 Discussion

9.3.1 Boys' and girls' relationships with school science

The findings from their responses offer an insight into pupils' perceptions of school science or science classes revealing varying levels of satisfaction with their science classes. From a more positive perspective, pupils agreed that school science is important, exciting and of high relevance.

Most pupils showed high enthusiasm for their science classes as they indicated that school science is interesting. The average scores for both boys and girls were on the 'agreeing' side of the neutral response value. One likely interpretation of such response may be that school science continues to attract pupils' interest and curiosity. This gives credence to an earlier finding from the same data in this study. In this study pupils expressed willingness to learn or were interested in learning about almost all the science topics listed in sections ACE of ROSE questionnaire.

Similarly, the responses to the items 'I think everybody should learn science at school', 'The things that I learn in science at school will be helpful in my everyday life' and 'School science has increased my curiosity about things we cannot yet explain' indicated that Ghanaian pupils were positive towards school science. They might regard school science very relevant to lives of people. A tentative explanation could be that they hold a positive view of the role science and technology can play in a less developed country like Ghana. One might expect such enthusiastic pupils more likely to express a belief in science and technology as a means to solving environmental problems (see section 8.3.1).

Average scores for pupils showed that they agreed with the statement 'I like school science better than most other subjects'. However, more boys than girls strongly agreed with this statement. This finding also fits well into the earlier choice of pupils regarding their high levels of interests in learning about almost all the science-related topics that were listed. Furthermore, the finding does support a number of studies in science education showing that boys have greater interest in science than girls (see for instance, Dawson, 2000; Osborne and Collins, 2001; Colley *et al*., 2003). However, the difference between boys and girls regarding this statement was not pronounced. This also is in line with the finding in the SAS study indicating that the gender differences in interest in science are less pronounced as compared to other developed countries (Sjøberg, 2000b).

As noted by Sjøberg (2002a), when people in less developed countries are still grappling with progress, growth and building their countries, scientists, technicians and engineers are seen as crucial for people's life and well-being. School science may be perceived as playing a crucial role for accomplishing these beliefs. One may ascribe this as one of the reasons that pupils tended to believe in the benefit in learning school science. It could also be interpreted that science which the pupils relate to at school inspires, excites and meets their aspirations. However, they are likely to experience some aspects of school science that are perceived to be mathematical and hence difficult (see for instance, Anamuah-Mensah, 1995; Sjøberg, 2002c).

A comparison of the responses of pupils on attitudes towards science classes with those of their interest profiles regarding a series of science-related topics listed in questions ACE, it appeared there were striking relationships between their responses. Most pupils, both boys and girls strongly agreed to almost all the statements that were used with pupils to evaluate their attitudes towards science classes. This might be expected since pupils had also shown high levels of interest in learning about almost all the science topics. A possible explanation for this observation may be that the positive attitudes of pupils towards school science are likely to have stimulated pupils' interests in almost all the science-related topics. Another explanation could be as noted in the Sjøberg's (2002b) SAS study, which revealed a strong positive attitudes towards science for pupils in the less developed countries. Perhaps, this might connect the curiosity they had about almost all the science-related topics on the list.

Pupils' interest profiles reflected strong interests in science topics that relate to health and well being[16]. The interest profiles tended to fit well into the high agreement levels among pupils for some aspects of science classes. These aspects are 'school science has taught me how to take better care of my health', 'school science has increased my appreciation of nature', 'school science has shown me the importance of science for our way of living', 'the things that I learn in science at school will be helpful in my everyday life' and 'I think that the science I learn at school will improve my career chances'.

9.3.2 Gender differences

Both boys and girls emerged with almost similar number of science topics when responses on the listed science-related topics of preference were analysed. However, there were few statistically significant differences (see table 7-3). The gender differences in attitudes towards school science were not also pronounced (see figures 9-1 and 9-2). For example, the top five strongly agreed statements (mean values in parenthesis and similar items are in boldface) associated with boys were:

> ***School science has taught me how to take better care of my health (3.60);***
> ***School science is interesting (3.59);***
> ***The things that I learn in science at school will be helpful in my everyday life (3.56);***
> ***School science has shown me the importance of science for our way of living (3.56)****; and*
> *School science has opened my eyes to new and exciting jobs (3.49).*

In contrast, girls were in a strong agreement with the following five statements:

> ***The things that I learn in science at school will be helpful in my everyday life (3.56);***
> ***School science has taught me how to take better care of my health (3.54);***

[16] The topics that appeared to have high personal relevance and were therefore attractive to both boys and girls were 'What can be done to ensure clean air and safe drinking water', 'What to eat to keep healthy and fit', 'how to exercise to keep the body fit and strong', 'How my body grows and matures' and 'What we know about HIV/AIDS and how to control it'.

School science is interesting (3.48);
School science has shown me the importance of science for our way of living (3.47)*; and*
I think that the science I learn at school will improve my career chances (3.39).

The choice Ghanaian pupils had made of school science as a subject to learn, appeared to be based on personal relevance or usefulness of science to their lives. In order words, it appeared to be based on their own interests, values and priorities.

Boys in general wanted to become scientists and seemed to like school science better than most other subjects. Surprisingly, boys slightly agreed that the things that they learn in science at school will be helpful in their everyday lives. Boys' choice to become scientists is likely to be based on the fact that it is economically significant for developing country like Ghana to have a high number of scientists or that they perceive scientists as important and respected personalities of society. This might mean that the image of the scientist is very positive among boys. Such views of boys are likely to impact positively on the motivation and willingness to engage in science study. Girls, on the other hand, tended to perceive their science classes to be interesting and that they were not in a strong agreement with the statement that they would like to become scientists as they engage in science classes. But rather, the things that they learn in science at school will be helpful in their everyday lives. They further agreed strongly that the school science they engage themselves in will improve their career chances. The picture that emerged from the data seemed to indicate that the image of the scientist was indeed different for boys and girls. The image is rather stereotypical and girls are likely to think of the scientist as male. However, school science may expose them to careers that relate to science, such as medicine and health where girls, typically dominate.

Both genders appeared to believe that the science they learn at school can show them the importance of science for their way of living and that school science can teach them how to take better care of their health. Despite the positive attitudes towards school science shown by both genders, girls in particular, slightly agreed that school science is not a difficult subject. This finding is in line with that of Jones' *et al*. (2000) study, which more females than males perceived science as difficult to understand. The perception of girls that science is somewhat difficult was probably demonstrated in the TIMSS 2003 study where in Ghana, there was a large gender difference in science achievements. In the TIMSS study, the boys performed better than the girls in all the content areas in science (Anamuah-Mensah *et al.*, 2004). In this present study, the findings also seem to give support to a statement by Sjøberg (2002b) that personal and societal interests are to be seen as key factors for engaging in science education. This is because despite the perception of school science as somewhat difficult, they also appreciate it.

These findings further appear to imply that pupils' attitudes towards science itself were generally positive (very high mean values). This is because pupils' choice to study science has been shown to be based on various reasons as seen from their responses. One of the reasons is that school science is both interesting and useful for job even though, they did not consider it to be easy with respect to girls. Pupils also seemed to give the impression that *relevance* is a reason for studying science and that it offers better employment prospects.

However, it is difficult to interpret these findings with any certainty. This is because studies elsewhere, which focused on gender issues indicated that the early childhood experiences may shape and develop girls and boys differently by virtue of the toys they are given to play with, the hobbies they are encouraged in, and the household jobs they are asked to help with (see for example, Hutt, 1972; Kelly, 1981; Murphy, 1990).

The levels of excitement, importance and relevance pupils hold for their science classes as indicated by them varied to some extent. However, in this study, the evidence from the analysis of the data subset on the theme 'My science classes' gives credence to an earlier assertion made by Schreiner and Sjøberg (2004).

They asserted that the affective factors of learning mean a lot for how pupils choose their future; and are also important determinants for the choice of school subjects. The findings in this study also agree with that in a study much earlier, where Gardner (1975) revealed that the gender differences in attitudes are suggestive of the fact that altitudes are far more important than cognitive factors on the account of subject choice.

9.3.3 Urban and rural pupils' relationships with school science

Looking at the overall picture, it is evident that both urban and rural school pupils showed positive attitudes towards science classes. However, urban pupils showed more positive attitudes than the rural group (see figures 9-3 and 9-4). Irrespective of geographical location of pupils, both groups of pupils agreed strongly with almost all the statements.

The analysis of their responses on some aspects of science classes suggests that most of the pupils were excited about their science classes. The result of this part of the study is fully consistent with the result obtained by Sjøberg (2000b; 2002a). He revealed that the enthusiasm shown by less developed countries to learn science is higher when compared with the developed societies. To interpret this observation becomes somehow challenging, as there may be a number of contributing factors within the less developed societies. Nevertheless, Sjøberg (2000b) indicated in his study that education appears not to be equally accessible to all children in developing countries due to parents' lack of adequate logistics and financial resources. The children are therefore likely to show a high motivation to study when educational opportunity is available and they might hold a positive view of their science classes. Another likely interpretation, which is quite debatable, may be that in a less developed society, like Ghana, science and technology is regarded as a panacea for an accelerated development of the country (see section 3.3.1). Science and technology-related professionals, such as scientists, engineers, technicians, technologists, agriculturists and medical doctors are still considered very important and of respected personalities in our society.

When pupils are aware of the key role science and technology can play in a nation's development, then they are likely to put up positive attitudes towards their science classes, though, both groups appeared to believe that their school science as a subject has some difficulty level. They agreed that some aspects of school science is difficult since the mean group scores for both urban and rural pupils were relatively closer to the neutral response value of 2.5. As already mentioned, the statement 'School science is a difficult subject' was inverted due to negative wording. In section 7.3.3 some of the items in the subsets ACE of the questionnaire, which focuses on science-related topics of interest, were clustered into content or context areas of the science subjects. Both urban and rural pupils were more interested in the context area of subjects than the content area which had been perceived to be more mathematical, for example, physics (see figures 7-3 and 7-4). This result seemed to be in line with both groups slightly agreeing that school science is not a difficult subject.

Another observation which needs commenting on is about the overall picture of rural pupils' responses to the 16 statements that were used to evaluate pupils' perception of and attitudes towards science classes. Rural pupils appear to be placed at a more disadvantaged position in terms of resources at science learning. The attitudes of the rural pupils towards science also appeared to be less positive than the urban group. This result appears to accord with that of Zuniga *et al*., (2005) and Webster and Fisher (2000). They revealed that the attitudes and aspiration of pupils in science learning are affected by their access to resources and that the lack of such resources might lead pupils to dislike science.

The same pattern of positive attitudes was also observed when one looks at the various qualities that pupils may have derived from engaging in their science classes. It appears the intentions of pupils to learn a subject may be based on the benefits that will accrue them. For example, they strongly agreed that the science classes they engage in might develop in them the following qualities: ‘The things that I learn in science at school will be helpful in my everyday life’, ‘School science has shown me the importance of science for our way of living’ and ‘School science has taught me how to take better care of my health’ (see figures 9-3 and 9-4).

One may suggest that the same line of thinking was applied by both urban and rural pupils to respond to some aspects of school science that can expose pupils to career choice that relate to science and technology. Both groups of pupils were strongly in agreement with the statements that the science they learn at school will improve their career chances. They were also of the view that school science can open their eyes to new and exciting jobs; and seemingly wanted to get jobs in technology or to become scientists. However, the rural school pupils’ interests in becoming scientists seemed to be more than that of urban pupils. This might be expected since rural pupils showed very high levels of interest in learning almost all the science- related topics listed in the subsets ACE of the ROSE questionnaire. Nevertheless, the data reveal that urban and rural pupils had very strong positive attitudes towards school science, with marked favourable attitudes towards personal benefits that can accrue from studying science.

The findings of the study and the views expressed by respondents towards science appeared to provide hope to science educators. The hope is that irrespective of geographical location of pupils, pupils hold positive attitudes towards school science. Science education programmes that are planned relevant to pupils are likely to attract their attention.

9.3.4 Urban and rural pupils’ differences

The top five strongly agreed statements (mean values in parenthesis and similar items are in boldface) associated with urban school pupils were:

School science is interesting (3.65);

> ***The things that I learn in science at school will be helpful in my everyday life (3.63);***
> ***School science has taught me how to take better care of my health (3.62);***
> ***School science has shown me the importance of science for our way of living (3.53)*****;** *and*
> *I think that the science I learn at school will improve my career chance (3.47).*

On the other hand, those of the rural pupils were:

> ***School science has taught me how to take better care of my health (3.50)****;*
> ***School science has shown me the importance of science for our way of living (3.50);***
> ***The things that I learn in science at school will be helpful in my everyday life (3.45)****;*
> *School science has opened my eyes to new and exciting job (3.43); and*
> *I would like to become a scientist (3.41).*

When one considers the statements appearing in both the urban and rural pupils' top five strongly agreed statements, urban pupils toped with the agreement levels. For example, 'the things that I learn in science at school will be helpful in my everyday life (mean value of 3.63 for urban as against 3.45); school science has shown me the importance of science for our way of living (3.53 as against 3.50 for rural); school science has taught me how to take better care of my health (3.62 for urban as against 3.50)'.

Most urban pupils, in particular, showed strong agreement with the statements: 'School science is interesting', 'School science has shown me the importance of science for our way of living' and 'I think that the science I learn at school will improve my career chance'. While rural pupils agreed strongly that school science has shown them the importance of science for their way of living, school science has opened their eyes to new and exciting job and would like to become scientists.

In spite that both groups indicated an agreement with the statement that school science is a difficult subject, they appeared positive towards science and also believed strongly that everybody should learn science at school. Perhaps, because they claimed that school science has increased their curiosity about things that could not yet be explained, they would like to have as much science as possible at school. However, both groups of pupils would like to get a job in technology. These findings seem to indicate that all groups irrespective of geographical location agreed that school science offers something that they can appreciate.

9.3.5 Ghanaian pupils' attitudes towards school science as compared to that of pupils from other countries

In all the diagrams in figure 9-5, it is noticeable that the majority of pupils from the low HDI countries demonstrated higher eagerness for their science classes than both the medium and high HDI countries. This is seen in the average scores of the statements used for the illustration. Both the boys' and the girls' average scores were far on the 'agreeing' side of the neutral response value for the less developed countries. This result might suggest that school science continues to attract pupils' interest and curiosity in the countries with low HDI values. Furthermore, the result seems to correlate well with an earlier finding from the same data in this study in which pupils expressed willingness to learn or were interested in learning about almost all the science topics listed in sections ACE of ROSE questionnaire.

However, when one considers the statement s*chool science is interesting*, the average scores with respect to all countries appeared to indicate that not all the young learners in the developed societies have lost interest in school science but rather, some are attracted to it. It appears that all is not yet lost with these countries as seen in many studies (see Black and Atkin, 1996; Schreiner and Sjøberg, 2004). Perhaps, young learners from the high HDI countries have other opportunities available to choose from. This suggestion is clearly demonstrated in their responses to the statement *I like school science better than most other* *subjects*. Other subject areas seemed to be more attractive to pupils from the developed countries. This is perhaps they have several options for their educational choice. Their decisions on educational choice appear to have a wider base of variety of educational interest that might be attractive to pursue for further studies. In such circumstance, studies in the sciences are not likely to attract the attention of the youth in the developed societies. They have a range of possible alternatives from which to choose the most interesting one. In the less developed countries, both genders liked school science better than most other subjects, but gender difference was pronounced in some of the Southern African countries (Swaziland, Zimbabwe and Botswana). In most of the countries, girls would have preferred other subject to school science.

However, the low HDI countries are yet to overcome the challenges of underdevelopment and would expect science and technology to play a major role in this. Against this background, the importance attached to science and technology related careers will continue to attract the attention of the populace. This was amply demonstrated in pupils' responses to the item *I would like to become a scientist*. The majority of pupils in the less developed and in some medium HDI countries appeared willing to become scientists, though, girls in the same Southern African countries, as noted above, did not show similar enthusiasms like the boys. It appears geographical closeness is seen as an underlying factor in responses than cultural similarities in the low HDI countries with respect to gender differences. This is also seen in the response profiles, which look similar for pupils in the Oriental countries (Malaysia, Philippines, India and Bangladesh). The pupils from the high HDI countries expressed unwillingness to become scientists and the girls in these countries were more hesitant. This finding is in line with those reported in many other studies, which indicated that the status of technological development of a country impacts on people's anticipation for the expected benefits of developments in science and technology. Pupils in developing countries had far more positive images of scientists and their potential for helping people than pupils in developed countries (Sicinski 1976, cited in Schreiner, 2006; Sjøberg, 2000a). It appears the developed countries are now in the post-materialistic era, where individual and societal expectations of the role of science and technology have been realized. Perhaps, the young learners in the high HDI countries also see science and technology in action all around and are likely to take the capabilities of science and technology for granted nowadays. They appear to concentrate rather on other challenges currently facing societies such as drug abuse, HIV/AIDS menace, environmental pollution and better governance.

Similar response profiles were seen in the item 'The things that I learn in science at school will be helpful in my everyday life'. The similarity in response profile appears to suggest that on the average, majority of pupils in almost all countries were positive towards school science, which might be regarded as very relevant to lives of people.

Conclusion

The gender differences in attitudes towards school science were not pronounced in Ghana. The general positive attitudes towards school science which all pupils had shown appeared to be based on personal relevance or usefulness of science to their lives. Most boys wanted to become scientists and seemed to like school science more than other subjects. To my surprise, boys slightly agreed that the things that they learn in science at school will be helpful in their everyday lives. Boys' choice to become scientists might be based on the perceived image of scientists as valued personalities of society.

Most girls, on the other hand, tended to perceive their science classes to be interesting but, they were not much interested to become scientists as they engage in science classes. They rather believed that the things they learn in science at school will be helpful in their everyday lives. They further agreed strongly that the school science will improve their career chances, as well as to help them to take better care of their health. Also, the majority of girls expressed interest in issues that relate to the human body.

The finding seems to indicate that both groups (urban and rural pupils) irrespective of their geographical location agreed that school science offers something that they can appreciate. The rural pupils agreed strongly that school science has opened their eyes to new and exciting job and would like to become scientists. However, urban pupils were in strong agreement with the statements: ‘School science has shown me the importance of science for our way of living’ and ‘I think that the science I learn at school will improve my career chance’. In my view, it appears school science becomes useful and meaningful to learners when it addresses relevance either personal or social.

In this chapter I have sought the Ghanaian pupils’ perceptions of the school science they engage in. I also made some comparisons of the perceptions with respect to gender, urban/rural school pupils and finally across countries. I will now look at the opinions these children also hold about the various aspects of the role of science and technology in society in chapter 10.

10. THE CHILDREN'S OPINIONS OF THE ROLE OF SCIENCE AND TECHNOLOGY

10.1 Introduction

Science and technology play an important role in the areas of food production, protection against and treatment of diseases and waste management. In these areas, engineers, scientists and technologists with their expertise may have the opportunity to help and make the world a better place to live (Schreiner, 2006). In the same study by Schreiner, it became obvious from empirical evidence that the level of technological development in a country is key factor for explaining the expectations people have of further developments in science and technology.

This chapter probes different aspects of how pupils perceive the role and function of science and technology in society. A section of the ROSE questionnaire labelled G has a title 'My opinion about science and technology'. The section is made up of 16 items that present some various aspects of the role of science and technology in society. The opinions of pupils about some roles that science and technology play in society could influence the motivation to engage in science. This section of the ROSE questionnaire was used to elicit such opinions of pupils.

10.2 Results

In table 10-1, the role and function of science and technology is presented in an increasing level of importance with respect to boys and girls. The table also portrays the opinions of pupils about science and technology. The procedure was repeated for urban and rural school pupils and is illustrated in the table 10-2.

10.2.1 Boys' and girls' opinions about science and technology

The responses on issues concerning science and technology in society appeared to indicate a widespread respect for science and technology issues. The response scores seemed to be of high values (greater than 2.5) in a 4-point Likert-type scale. On the average, the mean response values ranged from 3.64 to 2.70 for boys and from 3.47 to 2.69 for girls (see Appendix G). The opinions of boys and girls about the role of science and technology with mean score values greater than 3.0 were focused in this study since the mean score values for each of the 16 items were greater than 2.5.

The statements about the roles of science and technology as perceived by most of the boys and the girls to be important to society (mean score values > 3.0) are presented in the table below with similar opinions in boldface.

Table 10-1. Boys' and girls' most important aspects of science and technology in society (mean score value>3.0). Mean values sorted in descending order. Items appearing in both lists are in boldface.

Boys' opinions	Mean
G1. Science and technology are important for society	**3.64**
G4. Science and technology make our lives healthier, easier and more comfortable	**3.44**
G11. A country needs science and technology to become developed	**3.38**
G5. New technologies will make work more interesting	**3.37**
G3. Thanks to science and technology, there will be greater opportunities for future generations	**3.32**
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc	**3.22**
G6. The benefits of science are greater than the harmful effects it could have	**3.14**
G13. Scientists follow the scientific method that always leads them to correct answers	**3.11**
Girls' opinions	Mean
G1. Science and technology are important for society	**3.47**
G4. Science and technology make our lives healthier, easier and more comfortable	**3.41**
G11. A country needs science and technology to become developed	**3.35**
G3. Thanks to science and technology, there will be greater opportunities for future generations	**3.31**
G5. New technologies will make work more interesting	**3.30**
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	**3.22**
G13. Scientists follow the scientific method that always leads them to correct answers	**3.15**
G6. The benefits of science are greater than the harmful effects it could have	**3.02**

10.2.2 Gender differences in opinions about science and technology

There were some gender differences in opinions about science and technology, but they were not marked. There was only one out of the 16 statements, which showed statistically significant difference. The statement: 'Science and technology are important for society' was statistically significant at p-value of 0.001 in favour of boys. However, this aspect of science and technology appears on top of the opinion list of both boys and girls (see table 10-1). This difference shows no educational significance. This means that the gender differences in opinions about science and technology will not attract much discussion.

10.2.3 Urban and rural pupils' opinions about science and technology

Urban and rural pupils' views were positive about the roles that science and technology can play in a society. Their responses on all the listed issues about science and technology had mean values greater than 2.5, indicating the high expectations pupils have for science and technology. For example, the mean range of responses to each of the statements for urban pupils was from 3.55 to 2.63 and from 3.58 to 2.62 for rural school pupils.

In table 10-2, the results are presented in an increasing order of popularity among urban and rural school pupils. I start with the most popular and move to less frequently mentioned aspects of science and technology in society. All the numbers are mean values of pupils' responses to each of the roles of science and technology. However, the mean values greater than 3.0 are presented for both urban and rural pupils.

A similar pattern seemed to emerge from responses by urban and rural pupils. Most pupils from both urban and rural communities appeared confident about the likely achievements of science and technology. Probably, the majority of the urban and rural pupils seemed to have a strong belief in the following aspects of science and technology (see table 10-2).

Table 10-2. Urban and rural pupils' most important aspects of science and technology in society (mean score value >3.0). Mean values sorted in descending order. Items appearing in both lists are in boldface.

Urban pupils' opinions	Mean
G1. Science and technology are important for society	**3.55**
G4. Science and technology make our lives healthier, easier and more comfortable	**3.44**
G11. A country needs science and technology to become developed	**3.36**
G3. Thanks to science and technology, there will be greater opportunities for future generations	**3.35**
G5. New technologies will make work more interesting	**3.33**
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	**3.21**
G13. Scientists follow the scientific method that always leads them to correct answers	**3.19**
G12. Science and technology benefit mainly the developed countries	3.10
G6. The benefits of science are greater than the harmful effects it could have	**3.08**
Rural pupils' opinions	Mean
G1. Science and technology are important for society	**3.58**
G4. Science and technology make our lives healthier, easier and more comfortable	**3.40**
G11. A country needs science and technology to become developed	**3.37**
G5. New technologies will make work more interesting	**3.34**
G3. Thanks to science and technology, there will be greater opportunities for future generations	**3.26**
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	**3.23**
G6. The benefits of science are greater than the harmful effects it could have	**3.09**
G13. Scientists follow the scientific method that always leads them to correct answers	**3.04**

10.2.4 Differences in urban and rural pupils' opinions about S&T

Most of the differences in opinions of urban and rural pupils appeared not to be of any educational significance. Both groups held similar positive views on the list of aspects of science and technology. However, five out of sixteen items showed statistically significant differences with p-value less than 0.05 (see Appendix H). These significant differences are also shown in figure 10-1. On the average, there were three aspects of science and technology issues, which urban school pupils agreed more than their rural counterpart. For the rural pupils, they had more belief in two aspects of the science and technology issues.

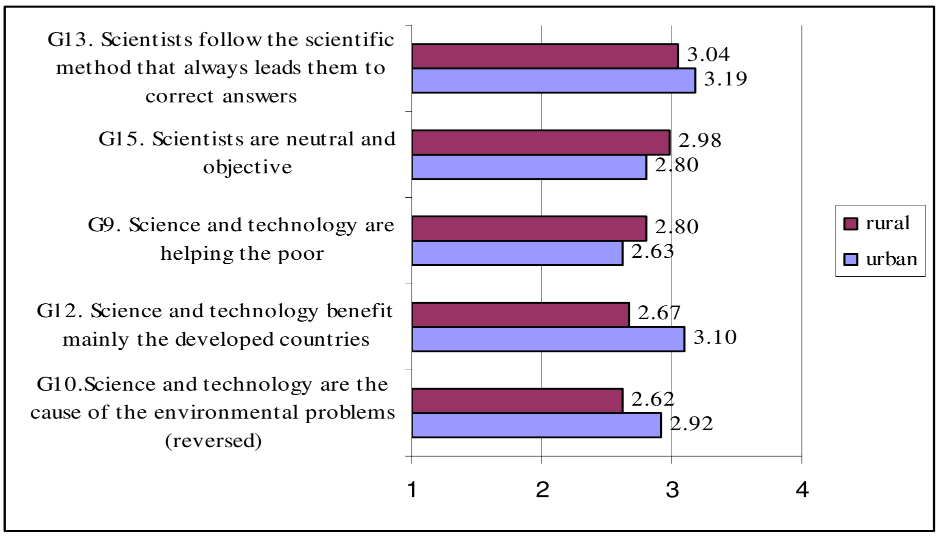

Figure 10-1. Statistically significant differences ($p<0.05$) in opinions for rural and urban school pupils. Mean values sorted in descending order for rural pupils.

10.2.5 Ghanaian pupils' opinions about S&T as compared to that of pupils from other countries

The results from the four examples (see figure 10-2) indicated that all pupils in all countries had positive views towards science and technology issues. However, the interest scores varied for boys and girls in some countries. The differences were not pronounced and were in rather a mixed order. For all the four illustrations, the majority of girls than boys in the low HDI countries were relatively of more positive views towards the roles of science and technology. However, in both high and medium HDI countries rather more boys shared those views.

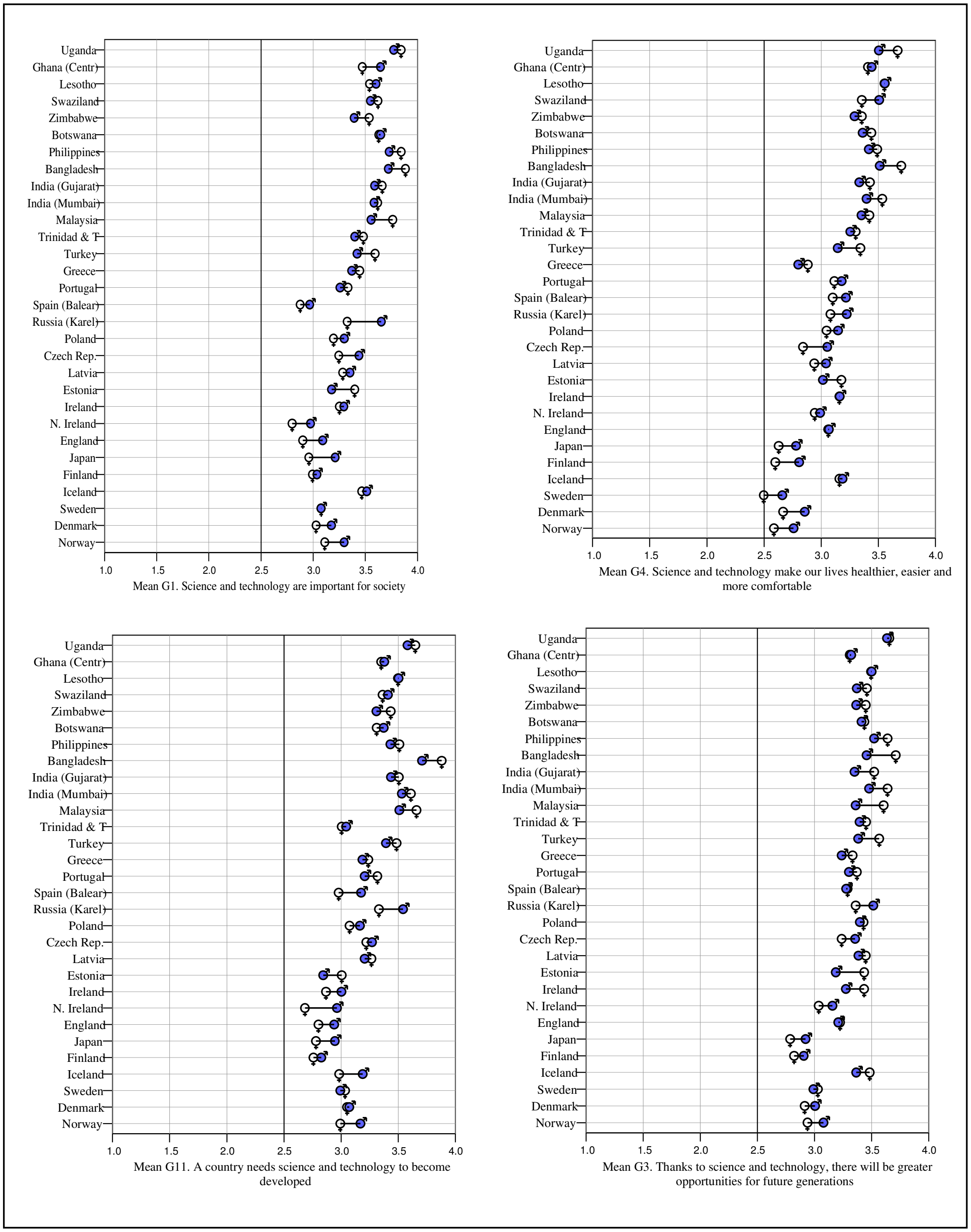

Figure 10-2. Illustrative examples of the pupils' opinions about science and technology across countries. See caption of figure 7-5 for diagram explanations.

10.3 Discussion

10.3.1 Boys' and girls' opinions about science and technology

It is noticed that science and technology enjoys a high popularity among both boys and girls. The interest among girls was on about the same level as boys (see section 10.2.1). A possible explanation for pupils' high level of interest in science and technology might be the belief they have in the role it can play in the development of the society. Another likely explanation could be that people in developing countries have not yet experienced some of the unintended catastrophes and risks that sometimes emerge through technological advancements. Their immediate concerns as a people from a developing country like Ghana, perhaps, are the solutions to the challenges of underdevelopment, which have been mentioned in this study. This is so as one considers the key role science and technology continue to play in the societies that have developed. It has also been cited elsewhere that the less developed a country is, the more positive young people are towards the role of science and technology in society (see Sjøberg, 2000b and Schreiner, 2006).

Perhaps, for these reasons above that all pupils showed strong agreement with similar statements like science and technology are important for society, science and technology make our lives healthier, easier and more comfortable, a country needs science and technology to become developed, new technologies will make work more interesting, thanks to science and technology, there will be greater opportunities for future generations, science and technology will find cures to diseases such as HIV/AIDS and cancer, the benefits of science are greater than the harmful effects it could have and that scientists follow the scientific method that always leads them to correct answers.

One is likely to conclude that both boys and girls in this study have confidence in the influence of science and technology on society when mean values of responses are considered. This could be the reason why pupils strongly recognized that science and technology are important for society, and might value the goods and the welfare coming with the applications of science and technology. For pupils, the goods and welfare may include healthier lives, more comfortable living and also opportunity to find cures to diseases such as HIV/AIDS, cancer. Both boys and girls appeared to appreciate the possibility of science and technology and perhaps believed more in the benefits of science and technology than the harmful effects. Such beliefs may influence the general perceptions of pupils about science and technology and are not likely to realize the limitations and possible side effects. The present generation of young learners in a less developed country is likely not to have a sense of balance of scientific arguments against social, political and moral perspectives in current socio-scientific issues. However, these responses can be seen to reflect the suggestion by Lewin (1993) that school science education in underdeveloped societies must be directed to meet the basic needs of health, nutrition and clean water.

Science and technology include aspects like technology in general, computer and information technology. Against this background, it seems the more positive view pupils hold towards science and technology, the greater the interest pupils have in technology education (see figures 7-1 to 7-4).

10.3.2 Gender differences in opinions about science and technology

Gender differences in opinions about science and technology were not pronounced. There was only one out of the sixteen statements, which showed statistically significant difference between girls and boys. As earlier mentioned, the gender differences in opinions about science and technology will not attract much discussion. However, this is very encouraging since girls in particular were holding positive opinions of science and technology similar in pattern with that of the boys. This makes a search for a possible *local* curriculum that is fair to both genders easier to find or construct.

It is important that school science education reflects this if it is to adequately prepare school leavers for a meaningful future world life to fully participate in social and economic development. More importantly, the focus of interest on technological matters is of central interest to both boys and girls, and that a change in content and the style of teaching to an extent will lead to a significant increase in the choice of physical science especially by girls.

10.3.3 Urban and rural pupils' opinions about science and technology

The responses from pupils on science and technology indicated that both urban and rural school pupils had high regard for science and technology. They strongly agreed with a number of statements concerning science and technology in society. Their perceptions of science and technology were that science and technology are important for society and also can make our lives healthier, easier and more comfortable. Perhaps, for such reasons, the majority of the urban and rural pupils in this study believed that a country needs science and technology to become developed and that new technologies will make work more interesting.

Many studies have indicated that the immediate concerns of pupils from developing countries about the application of science and technology are for general improvement and welfare of their societies (Schreiner and Sjøberg, 2006; Schreiner, 2006). It is against this background that perhaps, pupils have a great respect for science and technology. They also strongly believed that through science and technology there will be greater opportunities for future generations. They saw scientists as very brave and intelligent who follow the scientific method that always leads them to correct answers. They further believed that scientists can help people by finding cures to diseases such as HIV/AIDS and cancer. They also regarded the benefits of science to be greater than the harmful effects it could have.

The pupils' high expectations for science and technology appear to link well with their positive views towards science and technology in society. It might also connect with their high levels of interest to learn science and technology related issues at school.

The beliefs in several aspects of science and technology by pupils in the poor and underprivileged part of the world have been mentioned in some studies (see Sjøberg, 2000b; Sicinski, 1976). The results from this study of urban and rural pupils from Ghana revealed that pupils from these two different geographical areas expressed views about issues of science and technology that are positive. They appeared to show no emotional disposition towards the possible negative effects of the advancement in technology. The reason might be that they lack a general knowledge about some possible adverse effect of technological application in society. Against this background, it is likely that the perceived negative characteristics associated with scientists are not likely to emerge at early stage of schooling. This assertion is confirmed by some studies in science education which revealed that scientists continue to enjoy the position of respect in the developing societies (Sjøberg, 2000b; 2002a).

Looking at these responses as the true reflections of their opinions about science and technology, certainly, such views of the pupils could influence their motivation and willingness to engage in school science.

10.3.4 Differences in urban and rural pupils' opinions about S&T

In view of the fact that the urban and rural pupils are from two different environments, the differences in their opinions about science and technology issues in society were not pronounced. Issues that were perceived to be important by one group were also of equal importance to the other. Both the urban and rural pupils perceived that scientists are neutral and objective and that science and technology are helping the poor.

When the opinions were sought between urban and rural pupils about a question asking for the part of global world for which science and technology had played a major role in their developments, the responses revealed a large difference in opinion between the two groups. The urban pupils agreed more to the statement than rural pupils that science and technology benefit mainly developed countries (mean value was 3.10 as against 2.67 for rural pupils). The urban school pupils also were less in support with the statement that science and technology are the causes of the environmental problems. This statement, however, was reversed and the mean values were 2.92 and 2.62 for urban and rural school pupils respectively. A mean response value of 2.62 appears to indicate that most rural pupils were somehow indifferent to the statement since a value of 2.62 is on the right and closer to the neutral response value of 2.5.

For rural pupils, their stronger belief that science and technology are helping the poor appears to correlate well with their lesser belief that science and technology benefit mainly developed countries. On the other hand, urban pupils were less in agreement that science and technology are helping the poor. This also appears to correlate well with their strong perception that science and technology benefit mainly the developed countries. Pupils in rural communities probably are confident that the advancement in science and technology might have the capability of reducing incidence of poverty.

10.3.5 Ghanaian pupils' opinions about S&T as compared to that of pupils from other countries

From this study, even though, pupils from all countries appeared to have positive views about science and technology; studies have indicated that many young people mainly in highly developed societies appear to lose their interest in science and technology in schools (see Black and Atkin, 1996; Schreiner and Sjøberg, 2004). However, pupils from the less developed countries were found to be interested in learning everything including science and technology (Sjøberg, 2000b). A likely explanation could be that these young people in the developed countries continue to have respect for science and technology, but are just not interested in school science and technology as compared to other subjects.

Perhaps, the perceived expectations, values and images those pupils from the developed countries hold for school science and technology might be different from that of their counterparts in the less developed countries. In the developed countries, it is also possible that school science in its present state does not meet young people's values, expectations, priorities, among others. The majority of the youth in most of the developed societies are probably more concerned with some possible negative effects that could result through the application of science and technology. In the less developed countries, pupils appeared to believe in the benefits which science and technology can accrue them.

Conclusion

Based on pupils' responses, the majority of both the boys and the girls in this study were positive towards science and technology on society. Perhaps, this might be a reason that most pupils showed strong agreement with similar statements like science and technology are important for society, science and technology make our lives healthier, easier and more comfortable. Both genders believed that a country needs science and technology to become developed, new technologies will make work more interesting, thanks to science and technology, there will be greater opportunities for future generations. They were also positive that science and technology will find cures to diseases such as HIV/AIDS, cancer and that the benefits of science are greater than the harmful effects it could have. Most pupils further believed that scientists follow the scientific method that always leads them to correct answers. Such image that majority of pupils hold for science and technology might be a motivational factor towards school science for both genders, especially, when some aspects of the role of science and technology in society are mentioned during science teaching.

Gender differences were not pronounced. This is very encouraging since girls showed attitudes towards science and technology similar in pattern with that of the boys. It also makes a possible *local* curriculum that is fair to both genders easier to construct.

The results from the study of urban and rural pupils revealed that pupils from the two different geographical areas expressed views about issues of science and technology that were positive. They appeared to hold no negative view towards science and technology, such as possible adverse effect of technological application on society. The urban and rural pupils' positive views towards science and technology appeared to link well with their high levels of interest to learn science and technology at school.

In the next chapter I will explore what priorities pupils in this study hold towards potential future occupations or jobs as they relate to school science.

11. THE CHILDREN'S PRIORITIES TOWARDS FUTURE OCCUPATION

11.1 Introduction

One of the aims of learning science at school is to prepare individuals to take up science-related occupations or jobs (MEST, 2000; Aikenhead, 2005). In view of this, the important goal of a relevant science education is to recognize the perceived need to prepare and equip learners for future occupation. However, studies have shown that there seems to be any relationship between the science taught in school and scientific understanding needed for successful science-based occupations (Coles, 1997; Duggan and Gott, 2002).

On the other hand, some studies have revealed that some factors are taken into consideration by pupils when decisions on career choice or path are made (Shmurak, 1998; Lewis and Collins, 2001). Such factors are likely to be the different hopes and priorities pupils hold for their future that might be important for the choice of a future occupation or job. The knowledge of such hopes and priorities might be an important factor towards their learning when this set of job qualities is placed as part of the science curriculum emphasis. Furthermore, in order to establish what learners regard as relevant for future occupation the knowledge that teachers have of their learners is relied upon as an important factor for learning. It becomes even more important to interrogate learners themselves on what they regard as relevant based on the response to a questionnaire, such as the ROSE questionnaire or interview.

One subset of the ROSE questionnaire is labelled B and has a theme 'My future job'. This subset has a list of 26 items that present job qualities which are likely to be some of the hopes, aspirations and priorities pupils might perceive to be important for their future job. This may be an important element in their approach towards learning. Some of such job qualities may not exist for choice in the less developed countries. Nevertheless, the knowledge of job qualities pupils hope for their future occupation can be a key factor for the development of a culture of self-employment after leaving school. This is one of the challenges facing many of the developing countries.

11.2 Results

Pupils were invited to judge the personal relevance of each of these job qualities. The responses to these items are presented as in table 11-1 with mean scores of items in descending order. Similar analyses were done for urban and rural pupils and are also presented in table 11-2. The mean score of an item greater than 3 is considered in the tables.

11.2.1 Boys' and girls' job priorities

The mean responses values ranged from 3.52 to 2.04 for boys; for girls, it was from 3.38 to 1.93. Most of the scores seemed rather to be of high values in a 4-point Likert-type scale. From the results, one tends to conclude that both boys and girls strongly agreed on the importance of most of these qualities that majority of pupils would want to associate their future job with. Hence nearly all the statements achieved high priority from all pupils.

Table 11-1. Boys' and girls' priorities towards future job (mean score value>3.0). Mean values sorted in descending order. Items appearing in both lists are in boldface.

Boys' priorities	Mean
B25. Developing or improving my knowledge and abilities	**3.52**
B7. Working with machines or tools	**3.29**
B24. Becoming 'the boss' at my job	**3.29**
B2. Helping other people	**3.27**
B9. Using my talents and abilities	**3.24**
B20. Earning lots of money	**3.23**
B11. Coming up with new ideas	**3.20**
B15. Working with something I find important and meaningful	**3.12**
B4. Working in the area of environmental protection	**3.06**
B5. Working with something easy and simple	3.03
B1. Working with people rather than things	**3.01**
Girls' priorities	Mean
B25. Developing or improving my knowledge and abilities	**3.38**
B24. Becoming 'the boss' at my job	**3.33**
B2. Helping other people	**3.24**
B20. Earning lots of money	**3.22**
B11. Coming up with new ideas	**3.16**
B15. Working with something I find important and meaningful	**3.15**
B1. Working with people rather than things	**3.12**
B4. Working in the area of environmental protection	**3.10**
B9. Using my talents and abilities	**3.09**
B7. Working with machines or tools	**3.07**

Both boys and girls gave top priority to such qualities about jobs that will offer them opportunity to develop or improve their knowledge and abilities; and the possibility of becoming 'the boss' at the job and earning lots of money. Additionally, majority of them gave high priority to working with people rather than things and also helping other people around them. Most pupils wished to work with something they find important and meaningful; and to come up with new ideas. They also expressed interest in working in the area of environmental protection and a job that enables them to use their talents and abilities.

With reference to their ranking lists, almost similar items were ranked high and as well as at the bottom of the priority list for both boys and girls. Similar items are in boldface. The statements with mean values less than 2.5 are at bottom of the boys' list, which are:

> ***Working with something that involves a lot of travelling (2.39);***
> ***Having lots of time for my friends (2.21);*** *and*
> ***Working with animals (2.04)***

And for girls, the above statements about boys' future job also featured less on their priority list:

> ***Working with something that involves a lot of travelling (2.40);***
> ***Having lots of time for my friends, (2.20);*** *and*
> ***Working with animals, (1.93)***

However, there were differences in item mean values, but few were pronounced, which I will come back to it in more detail in the section that focuses on the discussion of results under this chapter. Relative to each other, boys appeared to be more positive about jobs that involve working with machines or tools and with something easy and simple where talents and abilities are used. Girls, on the other hand, concentrated their quality of job on becoming 'the boss' at the workplace, working in the area of environmental protection and working with people rather than things.

11.2.2 Gender differences in job priority

Only six out of twenty-six statements about some characteristics of future jobs that boys and girls prioritized showed statistically significant differences at p-value of 0.05. Two of the job characteristics were more attractive to most of the girls and majority of the boys were more attracted to four. Both boys and girls prioritized the importance of future job characteristics which were almost similar and equal in levels. However, it is noticeable in figure 11-1 that more girls than boys wanted to 'control other people' and make their own decisions at job. On the average, more boys than girls preferred developing or improving knowledge and abilities, working with something easy and simple, working with machines or tools and also appreciate the opportunity to use their talents and abilities.

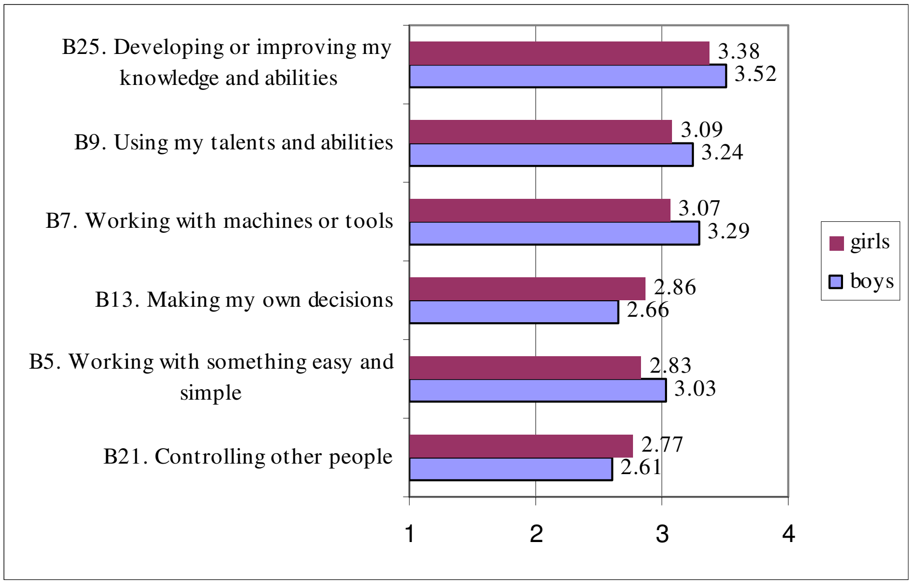

Figure 11-1. Statistically significant differences ($p<0.05$) in job priorities for girls and boys by mean values in descending order for girls.

11.2.3 Urban and rural school pupils' job priorities

The urban pupils' responses to the question of job characterises they prioritised had the mean values from 3.56 to 1.81. The mean values for the rural school pupils ranged from 3.33 to 2.25. Referring to the mean values, it appeared majority of the rural pupils in this sample would want to associate themselves with many of the job qualities.

Table 11-2. Urban and rural pupils' priorities towards future job (mean score value>3.0). Mean values sorted in descending order. Items appearing in both lists are in boldface.

Urban pupils' priorities	Mean
B25. Developing or improving my knowledge and abilities	**3.56**
B24. Becoming 'the boss' at my job	**3.40**
B2. Helping other people	**3.32**
B11. Coming up with new ideas	**3.27**
B7. Working with machines or tools	**3.26**
B4. Working in the area of environmental protection	3.18
B15. Working with something I find important and meaningful	**3.16**
B20. Earning lots of money	**3.16**
B9. Using my talents and abilities	**3.11**
B1. Working with people rather than things	**3.01**
Rural pupils' priorities	Mean
B20. Earning lots of money	**3.33**
B25. Developing or improving my knowledge and abilities	**3.28**
B9. Using my talents and abilities	**3.27**
B24. Becoming 'the boss' at my job	**3.18**
B2. Helping other people	**3.17**
B22. Becoming famous	3.16
B1. Working with people rather than things	**3.13**
B7. Working with machines or tools	**3.08**
B15. Working with something I find important and meaningful	**3.08**
B11. Coming up with new ideas	**3.06**
B.14. Working independently of other people	3.05

The urban pupils put these job qualities at the bottom of their priority list (mean values less than 2.5). Similar items in boldface:

> ***Working with something that involves a lot of travelling (2.44);***
>
> ***Having lots of time for my friends (2.01);*** *and*
>
> ***Working with animals (1.81).***

The job characteristics that appeared unappealing to rural school pupils were in the areas of

> ***Having lots of time for my friends (2.49);***
>
> *Having lots of time for my family (2.38);*
>
> ***Working with something that involves a lot of travelling (2.32);*** *and*

Working with animals (2.25).

11.2.4 Differences in urban and rural school pupils' job priorities

There were significant differences for 14 out of 26 statements about some qualities pupils perceive to be of importance for their future occupations with p-value less than 0.05, as shown in figure 11-2. However, some of the differences appeared not to be of educational significance as both groups tended to prioritise similar qualities either high or low on their ranking list. On the average, there were 8 different job qualities in which urban pupils ranked higher than rural pupils and there were also 6 qualities that rural pupils ranked relatively higher than those of the urban pupils on the 4-point-type Likert scale. Although, the distribution of interests among urban and rural pupils in some job qualities appeared significantly different, it is important to note that a job quality which was perceived to be important by one group might also be of the same importance to the other. For example, *Becoming 'the boss' at my job, Developing or improving my knowledge and abilities, Helping other people, Coming up with new ideas, Working with machines or tools, Working in the area of environmental protection* are some of the job characteristics which urban pupils found more appealing. These same characteristics were also of importance to the rural pupils. Similarly, rural pupils' preferences were more with job qualities, such as *Becoming famous, Working independently of other people, Using my talents and abilities, Earning lots of money* also attracted the attention of urban pupils, but of different mean values.

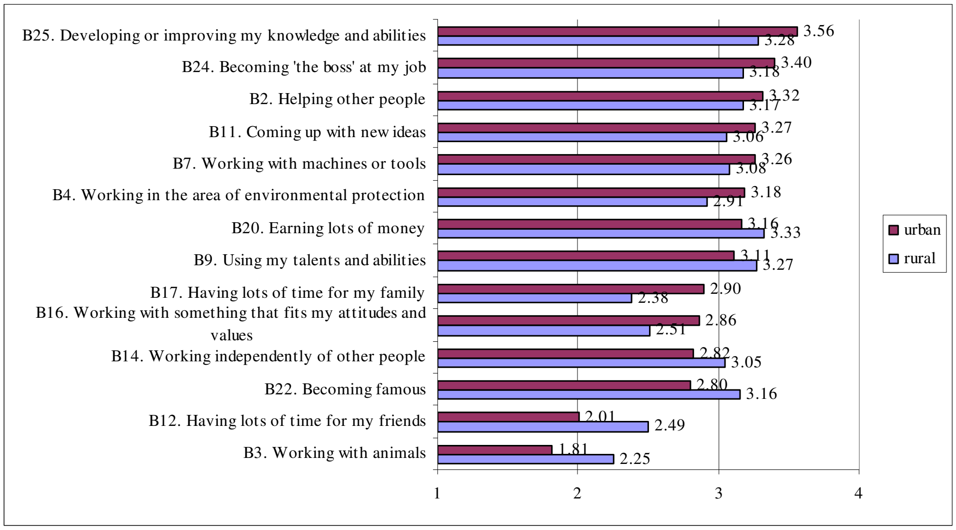

Figure 11-2. Statistically significant differences in job priorities for urban and rural pupils by mean values in descending order for urban pupils ($p<0.05$).

11.2.5 Ghanaian pupils' job priorities as compared to that of pupils from other countries

Figure 11-3 shows that most of the young learners in each country wanted a job that offers opportunity for them to develop or improve their knowledge and abilities. This job quality gained a mean score of more than 3.0 for both genders in all countries. For the majority of girls, this quality was more of importance to them than boys, except in Ghana. Also gender differences were not pronounced, but the differences were evident in the developed countries like Finland, Iceland and Sweden.

Responses to the item: 'working with machines or tools' showed large differences between countries and between boys and girls in each country. In Bangladesh, the gender difference appeared less pronounced. Most pupils in the developing countries believed in working with machines or tools, but gender differences were large and even larger in the developed countries, all in favour of boys. In all the developed countries, girls were unwilling to work with machines or tools.

In all countries, the majority of the pupils wanted to work in an area where they could help other people. This was more evident in the low and medium HDI countries than the high HDI countries. Also girls in almost all countries were more interested in this job than boys. However, boys and girls expressed almost equal desire to engage in jobs that offers opportunity to help others in Ghana. This shows a different response pattern all together with other countries.

Pupils in the less developed countries showed a lot of interest in becoming “the boss” at their job places. Most girls in the developed countries like the Scandinavian countries and Japan appeared not interested in becoming “the boss”. There was also a marked gender differences across these countries. On the contrary, girls showed slightly higher interests than boys in becoming “the boss” at their jobs in the less developed countries like Uganda, Ghana and Swaziland.

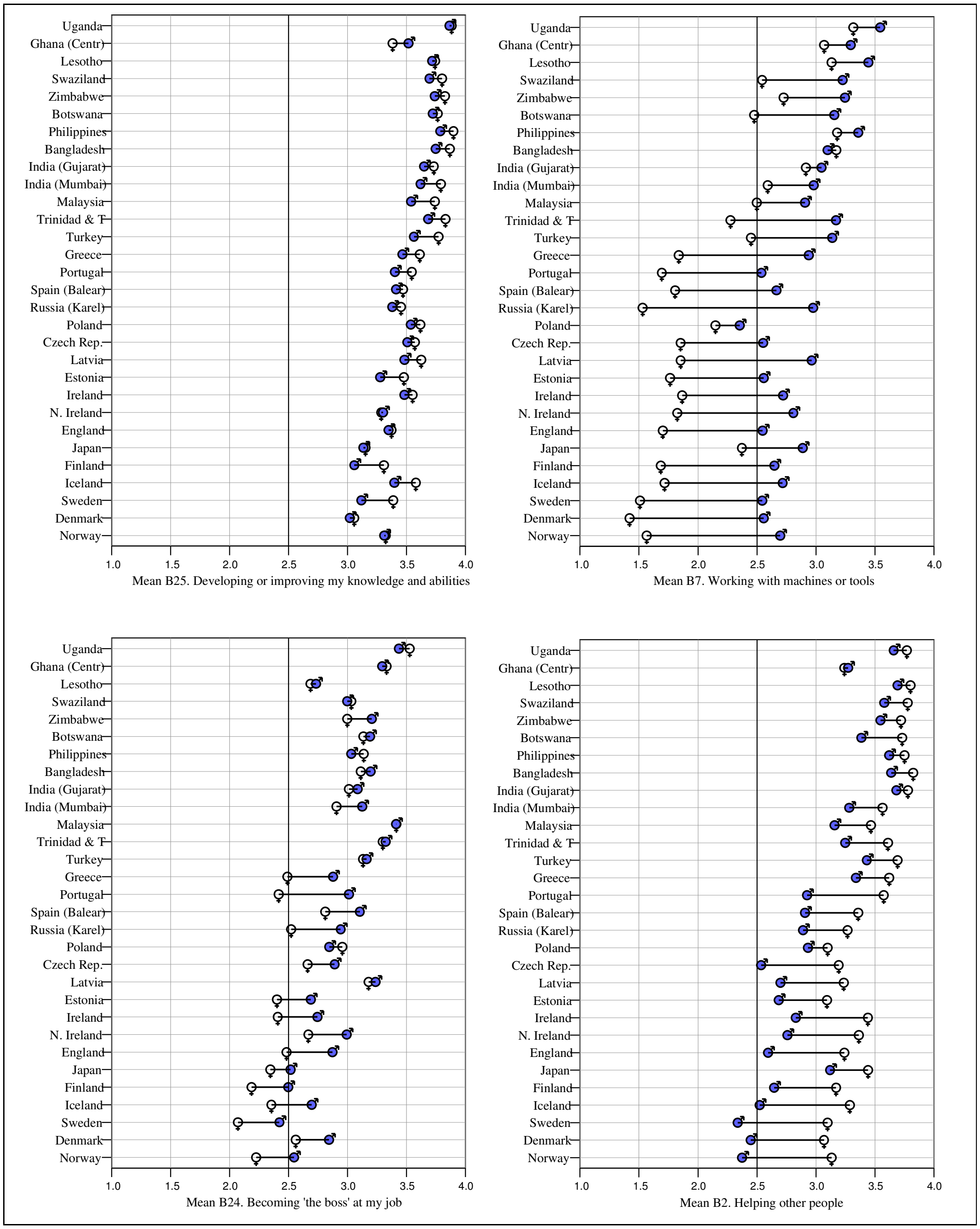

Figure 11-3. Illustrative examples of the pupils' job priorities across countries. See caption of figure 7-5 for diagram explanations.

11.3 Discussion

11.3.1 Boys' and girls' job priorities

The data from the subset 'My future job' in the ROSE questionnaire show that both boys and girls perceived most of the listed job characteristics or qualities to be important for their future job. The analysis of the responses to the statements indicated that twenty-three out of the twenty-six statements had mean values greater than 2.5. This may imply that most of them placed many of these characteristics high on their job priority list. Though, the mean values varied for boys and girls, the differences were not so pronounced.

The majority of the pupils wanted future jobs that open doors leading to the development or improvement of knowledge and abilities. Both boys and girls placed the above quality top on their list. This might imply that they are aware of developing their reasoning abilities and ingenuity. Therefore pupils could be helped to incorporate scientific content into their own thinking related to the world of work. When the scientific content that is taught in school matches some of the priorities pupils hold for the world of work, then there is a likelihood that the gap between what is learned in the classroom and the real life context of pupils could reduce considerably (see Anamuah-Mensah and Towse, 1995). The assumption here is that their interests in a job that enables knowledge and abilities to be developed is connected with the motive behind their choice for a future job that offers opportunity to use their talents and abilities.

Most of them wished to become "the boss" at their jobs, help other people, come up with new ideas and earn lots of money. An interpretation of these observations may be that a managerial position appears crucial for a good income and in addition be able to help people and also to come up with new ideas. References to the present challenges of economic conditions that pertain in many of the developing countries, both genders expected their jobs to be well paid. The reasons pupils preferred a job that would earn them lots of money might be economic. A study conducted with Finnish pupils in ninth grade in Finland (a developed country and a partner of ROSE) and adopting the ROSE questionnaire indicated that a good income was high on the job priority list for both genders (Lavonen *et al*., 2005). Similarly, good income seems to be the general desire of the majority of the youth. Clewell and Campbell (2002) in their study observed that some students especially females are deterred from participating in STME careers as a result of low salaries and inequitable distribution of career rewards.

Both boys and girls preferred to working with something they perceive to be important and meaningful. From the data in this study (see section 10.3.1), pupils also agreed strongly that they would like to get a job in technology. They indicated that new technologies will make work more interesting. They further agreed that science and technology are important for society and will help to eradicate poverty and famine in the world. When these responses from pupils are put together, one could conclude that Ghanaian pupils seemed to believe that a job in science and technology is important and meaningful. It is therefore not unexpected to find such an expressed importance of science and technology among pupils from a less developed country. The finding also gives credence to other studies that indicated that an important challenge in poor countries is related to the betterment of material conditions, economic growth and to improvement of health and the welfare system (Schreiner and Sjøberg, 2006). Also the level of development influences people's expectations to the benefits associated with the developments in science and technology (Sicinski, 1976). Consequently, science and technology can offer meaningful job opportunities for the present generation of young learners.

The analysis of pupils' responses showed that most of the pupils had positive view on many aspects of environmental protection (see section 8.3.1). The interest in working in the area of environmental protection attracted the attention of all groups of pupils. The reason for their concerns for the environment is likely to connect with environmental problems in developing countries that have continued to exist as a major challenge. The major cities and towns are more stressed with environmental degradation due to overpopulation. Perhaps, the inadequate knowledge in environmental studies could be a contributory factor. Proper method of educating the young learners in order to bring about significant change in attitude that will promote favourable action towards the environment is lacking. Nevertheless, we have earlier on noted that most pupils seemed to be interested in learning environmental education (see section 8.3.1). The development and validation of a reliable instrument such as that of the ROSE questionnaire, therefore becomes essential for assessing pupils' attitude to the environment.

The pupils' responses to a part of ROSE questionnaire that elicited different aspects of pupils' relationship to environmental challenges (question D) indicated a trust in themselves that they personally can influence what happens with the environment. They asserted the individual responsibility for the environment and not to be left to others or the rich countries. It appeared pupils believed working in the area of environmental protection that could open doors to carrying out actions that might be perceived to protect and improve the environment. They also showed high emotional dispositions towards environmental problems.

It is noticeable that both boys and girls gave similar very low priority to working with something that involves a lot of travelling, having lots of time for their friends and working with animals. These responses appeared to be gender-neutral since the differences were not pronounced. These same three items are at the bottom of their ranking lists. One might have expected that since they wanted a job that earns them a lot of money and also becoming 'the boss' at the workplace, they would have shown similar interest in a work that involves a lot of travelling. It is therefore, difficult to give possible reasons to such a low level of interest in travelling. In Ghana, the possibility of travelling regularly at a job is more associated with the top managerial position (the boss). Also earning extra income is more with jobs which entail a lot of travelling. It is likely that they are scared of the spate of accidents on the Ghanaian roads. It is also likely that they have limited ideas about what is involved in becoming 'the boss' or earning lots of money at workplace. Perhaps, they are just fascinated about such jobs. Other studies have revealed that girls typically select science-related careers that offer opportunity to help people, animals, plants, and the earth (Baker and Leary, 1995 and Shmurak, 1998). However, in this study both boys and girls wished to work in area of helping people and not working with animals. Working with animals is biology-related occupation and we note that biological topics are popular among the girls than with boys. It was unattractive to work with animals for both groups. Furthermore, biology has been traditionally viewed by girls as a more caring branch of science that focuses on living organisms and human health whereas physics is often viewed by girls as having to do with war and destruction (Jones *et al*., 2000). Perhaps, Ghanaian pupils perceive human beings to be much more important than animals, since they indicated in this study that they were not in agreement with the statement that animals should have the same right to life as people and strongly agreed that it is right to use animals in medical experiments if this can save human lives (see section 8.3.1). The reasons behind the pupils' unattractiveness to work with animals might be many. The responses of the respondents to the item *working with animals* might suggest that they may have a problem interpreting the concept 'animal'. Some of the respondents might have interpreted the concept 'animal' to mean wildlife. Associations dealing with wildlife or rights of animals are not common in Ghana. This observation may seem to suggest that pupils have no regard for animals. Also, in the study area, animals are not used for any form of labour such as traction and transport as it happens in the Northern part of the country. All these suggestions might have influenced pupils' responses to the item *working with animals.*

11.3.2 Gender differences in job priorities

Differences in job priorities for boys and girls appeared not pronounced. Most girls were more attracted to jobs that there is possibility of making their own decisions and controlling other people. Boys, unlike girls, preferred to work with something easy and simple, with machine or tools and jobs which abilities and knowledge can be developed and improved.

It is generally noted that women are poorly represented in the decision- making positions and top positions at workplaces, which are mostly occupied by men. Hence decision-taking and control of people appear to be the preserve of men. Women at best occupy the middle management positions and even at workplaces where there is equality in qualification and work experience, still women are perceived to exercise submissiveness (Twshene, 2003). This situation is very common with women in the developing countries and even in the education system at the pre-tertiary level, where women form the majority of the teaching profession, top positions are dominated by men. It is therefore, interesting and encouraging that the present generation of girls in this study shared with boys in most of the boys' job priorities. It appears girls would want to break away from the vocational expectations and goals of girls which are mostly confined to the 'traditional female occupations' (Jones *et al*., 2000), such as hair dressing, dress making and sales representative (Schwedes, 2005). At the JSS level, the range of the professional goals of girls is likely to be small since some studies revealed that, in many cases, students are not aware of their full range of job options and hence they may lack information and knowledge about pursuing higher education or careers in science (Kao and Tienda, 1998; Madill *et al*., 2000).

Granting that the responses to the question about their priorities regarding the qualities they hold for future job are true reflections of their perceptions of future job, then it may mean that in future, the earnings and career opportunities for the majority of girls in particular are likely to improve. They may resort to more prestigious professions that are science related. As already mentioned, we notice that most of the job qualities perceived by girls in this sample appeared to coincide with that of the boys. The perceived shift away of girls from the traditional lowering pay jobs that are normally typical of females to managerial positions where they can make their own decisions and control people might be due to some external influences (Twshene, 2003). Such external influences are likely to be inspiration from relatives and positive women role models from science and technology related fields that are often paraded at STME clinics; and the encouragement and support from girl-child education unit. This could be a good reason since a study conducted by Baker and Leary in 1995 revealed that many students do not know who a scientist is. According to Baker and Leary, girls in elementary and secondary schools have few women scientists as role models and that the students who do choose science frequently are likely to have positive role models to assist with their decisions.

The boys were more attracted to jobs that develop or improve knowledge and abilities, make work easy and simple and work that involves the use of machines or tools. These qualities were also of some levels of interest to girls. It appears the same reason might explain the boys' higher levels of interest than girls in a science topic relating to how to use and repair everyday electrical and mechanical equipment (see section 7.6.2). The more positive attitude of boys towards a job in technology is probably connected with their high interest in working with something easy and simple. A job in technology might also be perceived by boys to be an occupation where knowledge and abilities could be improved. The higher interest of boys than girls in the use of machines or tools and the use and repair of everyday electrical and mechanical equipment may affect girls negatively when it comes to the use of science equipment during the science practical lesson. The supply of science equipment is poor in most schools in Ghana, especially at lower levels. When boys and girls find themselves in a group during practical lesson, boys often perform the activity, as girls write down the readings. Consequently, girls are likely to have limited access to manipulate science equipment and may result in fewer opportunities than boys to develop their science practical knowledge and skills. These are assertions based on my own experience as a physics teacher from some schools in Ghana. In my view, as a science educator, a good concept formation requires hands-on and minds-on learning where learners work with practical apparatus and learn to reason about practical experiences and phenomena. With limited science practical knowledge and skills, majority of girls are likely to develop rote-learning attitudes in learning science subjects, especially in physics.

It is also noteworthy to observe that pupils, especially girls, appeared to be interested in learning about technology. However, they may do so well when their hopes for learning about technology are probably linked with helping people and also creating avenues of earning lots of money. I believe that when these values girls hold for future job are associated with professions in science and technology fields, girls may be attracted to taking science and technology at school. This is important because a study has shown that the male and female inherently have some natural differences, which account for the differentiation of sex roles in societies; and as well as their representation, interest and performance in some science subject (Reid, 2003).

11.3.3 Urban and rural school pupils' job priorities

A general high priority was expressed in most of the aspects of the future job. The two groups shared similar job qualities. However, the geographical background pattern in job priorities was not clear. Most of the qualities that attracted the attention of one group were also attractive to the other. There were differences, which were not very large. However, there is the need for some comments based on the responses.

Both urban and rural school pupils prioritized a future job where knowledge and abilities are either developed or improved, one can become 'the boss' at the workplace, help people, and come up with new ideas and use talents and abilities. Additionally, both groups gave high priority to working with something one finds important and meaningful, to working with people rather than things and to earn lots of money. These similar qualities about future job that are associated with both groups of pupils were in a mixed order. Most of the urban pupils on the average were more positive than their rural counterparts about becoming 'the boss' at the workplace. Perhaps, they would want to be in managerial position in order to come up with new ideas and be able to help people. All public and private establishments (higher educational levels, commerce and industry) are most often concentrated in urban areas and cities in

Ghana and that pupils' interests in such job qualities might have been influenced by the way they perceive people at the managerial positions in those establishments in view of the better conditions of service often attached to those positions. Urban pupils wanted a future job that enables one to work with machines or tools and in the area of environmental protection. The reason for urban pupils' interests in working with machine or tools might connect with their interests to learn about how computers work, which appeared at the top of the top ten of the most popular topics for which urban pupils wish to learn about (see table7-4). It appeared their interest in a job in the area of environmental protection links to an earlier expressed interest to learn about the science topics that were clustered as belonging to environmental education (see figures 7-3 and 7-4)

Motivational factor like earning lots of money had a very high response rate from all groups. The rural school pupils appeared more attracted to a job that will earn them a lot of money than the urban pupils, and also to become more famous and to work independently of other people (see figure 11-2). Poverty in Ghana is mainly in the rural areas. The majority of the rural dwellers are more unlikely to afford both nutritional requirements and essential non-food needs, such as education and health. It might be expected that pupils of such backgrounds would wish to associate themselves with a future job that can earn them lots of money. Perhaps, they would want that perpetual cycle of poverty and marginalization to be broken and have adequate educational resources and other needs that are most often tied to income levels. Other studies revealed rural pupils' excitement about science or science programmes. Also in these studies the rural pupils further indicated their willingness or interest in learning about almost all the science topics that are listed in those studies (Sjøberg, 2000b; Anderson *et al*., 2006). However, inadequate opportunities might result in fewer chances to enter school and science-based programmes or compete for jobs in the science fields (Zuniga *et al.*, 2005; Coley, 1999).

With reference to the responses to the part of the questionnaire items that was used to evaluate pupils' attitude towards science classes (see question F), the findings in this study indicated that, on the average, both groups were strongly in agreement with the statements that the science they learn at school will improve their career chances; learning school science has opened their eyes to new and exciting jobs. Perhaps, as a result of the role school science continues to play, pupils would like to get job in technology or would like to become scientists. However, the rural school pupils' interests in becoming scientists seemed to be more than that of the urban pupils. These findings may indicate that pupils, especially those from the rural settings, rather have high expectations and hopes in the school science. For example, they expected school science to offer them opportunity to improve their career chances; open their eyes to new and exciting jobs; earn them lots of money; become scientists in order to work independently of other people and perhaps, to become famous in the society.

However, both urban and rural pupils appeared not interested in jobs that demand a lot of travelling, to work with animals and to have lots of time for friends. But in addition, the rural school pupils appeared not attracted to a job that allows lots of time for the family. The rationale behind the unattractiveness of these aspects of future career for both groups appeared not quite clear. Nevertheless when the information about pupils' general perspectives of the environmental concerns was sought in this study, the same groups of pupils indicated their disagreement with the statements that 'animals should have the same right to life as people' and also disagreed that it is right to use animals in medical experiments if this can save human lives. The reason behind such responses could be in line with the reason for the pupils' disinterest to work with animals. Especially for the rural sample where majority of the adult population is engaged in subsistence farming. In such a community, the domestic animals have a high value. One might have expected high interest in this work for the rural pupils. It is also possible that at the JSS level, pupils might interpret 'having lots of time for friends or family' to mean having time for leisure. Helping other people (or dependents) appears more attractive to an individual than having leisure time for friends or family in the

Ghanaian society, perhaps, due to the extended family culture. Ghanaian pupils are not likely to associate a future occupation with having lots of time for friends or family.

11.3.4 Differences in urban and rural school pupils' job priorities

There were some differences between urban and rural pupils on some factors that appear important for the choice of a future job. Pupils in each group seemed to have some personal relevance in each of those factors with group differences emerging to be significant. The urban pupils were more interested in working in the area of environmental protection.

Many pockets of urban areas in developing countries are still faced with harsh conditions of poor sanitation and other forms of pollution. The urban poor live in slum areas. One is likely to acknowledge the importance the urban pupils attached to working in the area of environmental protection. It is also possible that an environmental awareness might have been created among the urban pupils. This is evident from responses by urban pupils to a section of the questionnaire that has a list of items that has the theme ''Me and the environmental challenges'' (question D). The question assesses pupils' attitudes and their sense of responsibility for environmental issues. The findings on such issues in this study indicated that urban school pupils believed in the involvement of everybody in the environmental protection and were also in strong agreement that people should care more about the protection of the environment. Most of them had the belief that individual involvement can make significant contribution to environmental protection. The reasons for such positive attitudes towards the environment could be linked to the interest to work in the area of environmental protection (see sections 8.2.2 and 8.3.2).

However, rural pupils were of more interest than urban pupils to work in areas where they would earn lots of money. Generally, poverty indicators point to the persistent inequalities in the Ghanaian society. The inequality is more pronounced in the rural areas in general and the marginalized communities in particular (Sundrum, 1990). Many rural dwellers in Ghana have to work on their farms to subsist and in some cases some pupils work to support the family budget. In order to overcome some of the harsh conditions of poverty, it is expected that pupils in such communities would likely prefer a future career that would earn them lots of money.

As a developing country, the range of options available for the youth at making educational choice that could potentially develop abilities and expose talents may be limited. Nevertheless, it is my hope that as science educators, our knowledge of pupils' values and priorities they hold for future job during their science course may open up the youth to science and technology studies that might provide them with opportunities for meaningful jobs.

11.3.5 Ghanaian pupils' job priorities as compared to that of pupils from other countries

In all countries, interests in a future job that encourages the development of knowledge and abilities suggest that school science should pay more attention to developing pupils' reasoning abilities, expressiveness and creativity. Seemingly, this would enable them incorporate scientific content into their own thinking which could be applied later to the science-related jobs. This could be achieved when pupils take the responsibility of their own learning and teacher acting as a facilitator. This job quality is important across all cultures and girls in almost all countries placed such quality higher than boys on their priority lists.

On the average, there was very large gender difference with a future job that involves the use of machines or tools. The gender difference was in favour of boys for all countries. In the low and medium HDI countries, most of the girls showed slight interests. This suggests that in all countries the majority of girls appeared not have been exposed to the use of machines and tools, which could have motivated them to develop interest in the use of machines and tools. The unfamiliar use of tools may impact negatively on their practical skills and the use of science equipment during their science lessons. Perhaps, the very large gender difference emerging against girls in the high HDI countries might be interpreted differently. In the light of the vast opportunities available in their societies, girls could construct their own identities through one's personal professional choices. For example, it is evident in their responses that the majority of girls would want to be identified more than boys with jobs that would enable them to give a helping hand to other people. This result supports other studies elsewhere that revealed that girls prefer science-related careers that present opportunity to help people (see Baker and Leary, 1995 and Shmurak, 1998). However, in Ghana, both boys and girls expressed similar desires to work in areas of helping people.

Many of the girls in the high HDI countries were not very interested in jobs where they might become "the boss". One would have expected those societies where there are equal opportunities, and no cultural barriers to developing individual potential, girls would have appeared more than ready to compete equally with boys for managerial positions at the workplace. An interpretation could be that as a result of the equitable distribution of career rewards, being at the top position at a workplace might not be a factor in what they want to be known. Another interpretation is a reflection of boys and girls in those societies having different values. However, in the low HDI countries, such top positions are highly respected in the society and they are more likely to be attractive to both boys and girls.

Conclusion

The majority of the Ghanaian pupils had a general interest in working in area of technology. They found job in technology important and meaningful to themselves and the society. In this study, pupils also agreed strongly that they would like to get a job in technology and further indicated that new technologies will make work more interesting. The study further revealed that science and technology are important for society and will help to eradicate poverty and famine in the world. When these responses from pupils are collated, the conclusion is that Ghanaian pupils in this sample believed that a job in science and technology is important and meaningful.

Boys appeared more positive than girls about becoming scientists and also wanted to study more science than other subject. It becomes uncertain whether the boys' typical plan about becoming scientists emanate from their own ability or the envious nature people hold for scientists in our society. Girls wanted jobs where there will be opportunity to use and develop talent and ability and also to assume managerial or top positions in a workplace. They were also interested in a job where they will be free to make their own decisions. Despite these values, both boys and girls also wanted a job that will earn themselves lots of money, but did not want to have lots of time for family.

Both urban and rural school pupils prioritized a future job where knowledge and abilities are either developed or improved; becoming 'the boss' at the workplace; helping people; and coming up with new ideas and using talents and abilities. In addition all of them gave high priority to working with something one finds important and meaningful, to working with people rather than things and to earn lots of money.

Urban pupils on the average were more positive than their rural counterparts about becoming 'the boss' at the workplace and perhaps, to be in managerial position in order to come up with new ideas and be able to help people. A motivational factor like earning lots of money had very high response rate from all groups. The rural school pupils appeared more attracted than their urban counterparts to jobs that will earn them lots of money, to become famous and to work independently of other people.

It is important for teachers to educate pupils on the industrial, economic or social applications of what they teach in order that pupils could be motivated towards their future occupations. This is likely to help pupils aim at those applications and study towards it.

In the next chapter, I will elicit and discuss pupils' outside of school time experiences that might have bearing on what they learn in school science.

12. THE CHILDREN'S OUT-OF-SCHOOL SCIENCE EXPERIENCES

12.1 Introduction

Sjøberg (2002a) is of the view that there is a general acceptance that all teaching should 'build on' the interest and experience of the child. Teaching content must have some relevance, and it must fit into the personal curiosity or societal context of the child. Yet other studies elsewhere have indicated that in most countries there is a considerable gap between what is learned in the classroom and the real life context of the pupil (Anamuah-Mensah and Towse, 1995; Stevenson, 1995 and Muskin, 1997, cited in Towse *et al.,* 2005). Criticism continues to be levelled against traditional science for its lack of relevance for the everyday world (Osborne and Collins, 2000).

Pupils are likely to learn better when learning is related to real life situations. In other words, pupils might learn science with better understanding when there is a closer connection between classroom learning, the environment and the practical experiences of the pupils. Knowledge of pupils' out-of-school experiences could be a valuable asset for the teacher. It may provide the teacher with an insight into a variety of out-of-school experiences that might exist among the young learners. Such experiences, which are fair and relevant to all groups of learners, can be cited from to enhance understanding, when new concepts and skills are presented in science classes.

A subset of the ROSE questionnaire is labelled H and has the theme 'My out-of-school experiences'. This was used to elicit such experiences. This theme or subset is an inventory of some 61 activities that may be used to determine what kind of experiences pupils have outside of school time that might have bearing on the teaching and learning of science. The subset has a large number of varied activities in order to balance relevant activities from different continents and cultures and also to have activities that are fair to all groups.

12.2 Results

The data were sorted based on the mean score of each activity and given as the ten top and the least ten experiences by boys and girls, as well as urban/ rural pupils. These are presented in tables 12-1, 12-2, 12-4, and 12-5. Appendix I gives full result. Each activity has four possible responses: "Never", "Seldom (once or twice)", ''Sometimes'' and "Often (many times)".

The scale ranges from 1 to 4. A mean value of 2.5 is considered in this chapter as the mid-point of the scale and not the neutral response value, since the scale ranges from "Never" to "Often". It is also seen that mean scores fell within a range from 3.37 to 1.89 for boys and 3.55 to 1.81 for girls. The urban and rural pupils' mean values ranged from 3.39 to 2.09 and from 3.54 to 1.54 respectively. An overall mean score does not carry any direct meaning but they may be used to indicate whether boy/girl activities or urban/rural activities have been sampled in a balanced way.

12.2.1 Boys' and girls' out-of-school experiences

The findings are presented with ten most and ten least experiences or activities for gender. Boys and girls came out with some similarity in activities and in a rather mixed order but with slightly difference in overall mean scores in favour of the boys. The most outside of school experiences selected by boys and girls are as indicated in table 12-1. The items appearing on both lists are in boldface.

Table 12-1. The top ten of the most outside of school experiences for girls and boys. Mean values sorted in descending order.

Boys' activities	Mean
H54. cooked a meal	**3.37**
H22. made a fire from charcoal or wood	**3.14**
H27. taken medicines to prevent or cure illness or infection	**3.13**
H23. prepared food over a campfire, open fire or stove burner	**3.03**
H12. read about nature or science in books or magazines	**3.00**
H43. used a measuring ruler, tape or stick	**2.95**
H60. used tools like a saw, screwdriver or hammer	2.93
H13. watched nature programmes on TV or in a cinema	**2.91**
H17. planted seeds and watched them grow	**2.91**
H52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works	2.87
Girls' activities	**Mean**
H54. cooked a meal	**3.55**
H22. made a fire from charcoal or wood	**3.13**
H27. taken medicines to prevent or cure illness or infection	**3.11**
H23. prepared food over a campfire, open fire or stove burner	**3.11**
H43. used a measuring ruler, tape or stick	**2.98**
H12. read about nature or science in books or magazines	**2.97**
H13. watched nature programmes on TV or in a cinema	**2.92**
H17. planted seeds and watched them grow	**2.79**
H14. collected edible berries, fruits, mushrooms or plants	2.74
H29. been to a hospital as a patient	2.69

On the average, both genders had almost similar most frequent experiences in outside of school time activities. For example, they most frequently cooked a meal, made a fire from charcoal or wood, prepared food over open fire or stove burner. Both boys and girls had often sought medical treatment; and they had also experienced nature or science through books, magazine, films, and TV programmes. They further indicated high experiences that included the use of measuring ruler, tape or stick and planting seeds and watching them grow.

Boys reported having experiences in the use of tools like a saw, screwdriver or hammer and also in an activity that involves the opening of a device, such as radio, watch, computer and telephone to find out how it works. On the other hand, girls had outside of school activities that included collecting edible berries, fruits, mushrooms or plants and had also experienced being in a hospital as a patient.

The ten least experiences or activities for gender are presented in table 12-2. Similar items that appear on the lists of both boys and girls are in boldface.

Table 12-2. The ten least of outside of school experiences for girls and boys. Captions, as in Table 12-1.

Boys' activities	Mean
H61. charged a car battery	**2.14**
H24. sorted garbage for recycling or for appropriate disposal	**2.13**
H11. made dairy products like yoghurt, butter, cheese or ghee	2.13
H51. used a word processor on the computer	2.12
H15. participated in hunting	**2.12**
H41. used a stopwatch	2.10
H45. sent or received an SMS (text message on mobile phone)	2.08
H33. used an air gun or rifle	**1.93**
H37. used a windmill, watermill, waterwheel, etc	**1.93**
H30. used binoculars	**1.89**
Girls' activities	Mean
H57. used a crowbar (jemmy)	2.07
H24. sorted garbage for recycling or for appropriate disposal	**2.06**
H37. used a windmill, watermill, waterwheel, etc	**2.06**
H32. made a bow and arrow, slingshot, catapult or boomerang	2.04
H59. mended a bicycle tube	2.00
H61. charged a car battery	**1.97**
H16. participated in fishing	1.93
H30. used binoculars	**1.90**
H33. used an air gun or rifle	**1.85**
H15. participated in hunting	**1.81**

12.2.2 Gender differences in out-of-school experiences

The differences in out-of-school experiences for boys and girls are shown in table 12-3 and supplemented by Appendix I. The differences were sorted in ascending order, where the boys' mean is subtracted from the girls' mean. The p-value in the last column is a measure of the statistically significant difference. There were significant differences for 17 out of the 61 outside of school time experiences. The activities that showed statistically significant difference at $p<0.05$ were focused. More of the boys than girls reported more of the out-of-school activities. For the 17 activities, 14 out of it went in favour of boys as against 3 for girls. Boys' activities included the following: making a bow and arrow, slingshot, catapult or boomerang; using tools like a saw, screwdriver or hammer; using a wheelbarrow; changing or fixing electric bulbs or fuses; mending a bicycle tube and using a crowbar (jemmy). Also boys had more experience than girls in making an instrument (like a flute or drum) from natural materials; putting up a tent or shelter; opening a device (radio, watch, computer and telephone) to find out how it works; making a model such as toy plane or boat and charging a car battery.

Girls' experiences that were significantly different from that of the boys were cooking a meal; knitting and weaving; and baking bread, pastry and cake.

Table 12-3. Statistically significant gender differences in extracurricular activities. Mean values are given for girls and boys, with standard deviation (SD) and p-value < 0.05. Sorted by mean differences between girls and boys in ascending order

	Girls	Boys	Mean Difference	
Out-of-school activities	Mean(SD)	Mean(SD)	Girls-Boys	p-value
Made a bow and arrow, slingshot, catapult or boomerang	2.04 (1.08)	2.48 (1.1)	-0.45	0.000
Used tools like a saw, screwdriver or hammer	2.51 (1.07)	2.93 (0.96)	-0.42	0.000
Used a wheelbarrow	2.41 (1.08)	2.74 (1)	-0.33	0.000
Changed or fixed electric bulbs or fuses	2.23 (1.12)	2.56 (1.15)	-0.33	0.000
Mended a bicycle tube	2 00 (1.14)	2.32 (1.14)	-0.32	0.000
Used a crowbar (jemmy)	2.07 (1.08)	2.38 (1.03)	-0.31	0.000
Participated in hunting	1.81 (1.05)	2.12 (1.1)	-0.31	0.000
Made an instrument (like a flute or drum) from natural materials	2.43 (1.09)	2.72 (0.98)	-0.29	0.000
Put up a tent or shelter	2.25 (1.13)	2.51 (1.11)	-0.27	0.000
Participated in fishing	1.93 (1.11)	2.18 (1.15)	-0.25	0.001
Opened a device (radio, watch, computer, telephone, etc.) to find out how it works	2.67 (1.16)	2.87 (1.1)	-0.20	0.006
Made a model such as toy plane or boat etc	2.35 (1.1)	2.55 (1.05)	-0.20	0.004
Cared for animals on a farm	2.46 (1.16)	2.66 (1.15)	-0.20	0.008
Charged a car battery	1.97 (1.19)	2.14 (1.25)	-0.18	0.022
Cooked a meal	3.55 (0.74)	3.37 (0.87)	0.18	0.001
Knitted, weaved, etc	2.45 (1.12)	2.15 (1.07)	0.30	0.000
Baked bread, pastry, cake, etc	2.65 (1.16)	2.28 (1.19)	0.37	0.000

12.2.3 Urban and rural school pupils' out-of-school experiences

Table 12-4 shows the ten top most popular of all the 61 out-of-school experiences for both urban and rural school pupils. Seven out of the ten most frequently done outside of school time activities were similar for urban and rural pupils in this study, but there were slight differences in mean values for those activities.

Table 12-4. The top ten of the most outside of school experiences for urban and rural school pupils. Captions, as in Table 12-1.

Urban pupils' activities	Mean
H54. cooked a meal	**3.39**
H12. read about nature or science in books or magazines	**3.14**
H27. taken medicines to prevent or cure illness or infection	**3.12**
H43. used a measuring ruler, tape or stick	**3.08**
H22. made a fire from charcoal or wood	**3.02**
H4. used a compass to find direction	2.95
H13. watched nature programmes on TV or in a cinema	**2.94**
H52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works	2.92
H23. prepared food over a campfire, open fire or stove burner	**2.92**
H3. read a map to find my way	2.89
Rural pupils' activities	Mean
H54. cooked a meal	**3.54**
H22. made a fire from charcoal or wood	**3.31**
H23. prepared food over a campfire, open fire or stove burner	**3.29**
H27. taken medicines to prevent or cure illness or infection	**3.13**
H13. watched nature programmes on TV or in a cinema	**2.87**
H14. collected edible berries, fruits, mushrooms or plants	2.84
H17. planted seeds and watched them grow	2.83
H55. walked while balancing an object on my head	2.81
H43. used a measuring ruler, tape or stick	**2.79**
H12. read about nature or science in books or magazines	**2.75**

The kind of shared experiences for pupils of the two different geographical backgrounds (urban/rural), which are in boldface included the following: cooking a meal; reading about nature or science in books or magazines; taking medicines to prevent or cure illness or infection; using a measuring ruler, tape or stick; making a fire from charcoal or wood; watching nature programmes on TV or in a cinema and preparing food over a campfire, open fire or stove burner.

Three items describing different activities stood out distinctively on each of the urban and rural pupils' lists of out-of-school activities. For the urban pupils, the activities such as opening a device (radio, watch, computer and telephone) to find out how it works; using a compass to find direction and reading a map to find my way were also among the ten most popular activities. The rural pupils, on the other hand, reported on these activities that are absent on the ten top list of activities of the urban counterparts. These activities included collecting edible berries, fruits, mushrooms or plants; planting seeds and watching them grow and walking while balancing an object on the head.

Among the activities that were selected by pupils, the least outside of school time experiences for urban and rural pupils are presented in table 12-5. There were few activities which showed similarities among the two groups. These have been indicated by boldface in table 12-5. They all lacked in experiences in charging a car battery; using a windmill, watermill and waterwheel; using binoculars and using an air gun or rifle.

Table 12-5. The least ten of outside of school experiences for urban and rural school pupils. Captions, as in Table 12-1.

Urban pupils' activities	Mean
H20. knitted, weaved, etc	2.38
H57. used a crowbar (jemmy)	2.35
H61. charged a car battery	**2.34**
H32. made a bow and arrow, slingshot, catapult or boomerang	2.32
H24. sorted garbage for recycling or for appropriate disposal	2.30
H37. used a windmill, watermill, waterwheel, etc	**2.22**
H16. participated in fishing	2.15
H30. used binoculars	**2.13**
H15. participated in hunting	2.10
H33. used an air gun or rifle	**2.09**
Rural pupils' activities	Mean
H48. used a dictionary, encyclopedia, etc. on a computer	1.67
H37. used a windmill, watermill, waterwheel, etc	**1.65**
H41. used a stopwatch	1.64
H61. charged a car battery	**1.64**
H49. downloaded music from the internet	1.60
H33. used an air gun or rifle	**1.60**
H50. sent or received e-mail	1.57
H45. sent or received an SMS (text message on mobile phone)	1.57
H30. used binoculars	**1.56**
H51. used a word processor on the computer	1.54

12.2.4 Ghanaian pupils' out-of-school experiences as compared to that of pupils from other countries

The four examples illustrating Ghanaian pupils' out-of-school experience measured against that of pupils from other countries are presented in figure 12-1. In all the countries, the majority of the respondents had often cooked a meal. The majority of pupils from the low HDI countries had done it most often. Across all cultures, girls were found to have done cooking most of the time. Even, in Ghana, where both boys' and girls' experiences seemed to coincide with almost all of the examples presented in this section, girls comparatively had cooked a meal more often. However, boys were found more involved in making a fire from charcoal or wood than girls in the medium and the high HDI countries. In the low HDI countries, it was found in a mixed order for Uganda, Zimbabwe and Botswana.

The statement: ‘prepared food over a campfire, open fire or stove burner’ received varied responses and also showed no clear pattern across countries and between genders. In one culture, the gender difference was in favour of girls, but favoured boys in another culture, and in Ghana, both genders shared in this activity. But in all the responses, pupils in the low HDI countries often engaged in this activity.

In all countries, the majority of pupils had taken medicines to prevent or cure illness or infection irrespective of level of development or cultural and geographical backgrounds. In most of the countries, pupils had more often taken medicine. But in Ghana, Lesotho and part of India, both genders were equally involved in this activity.

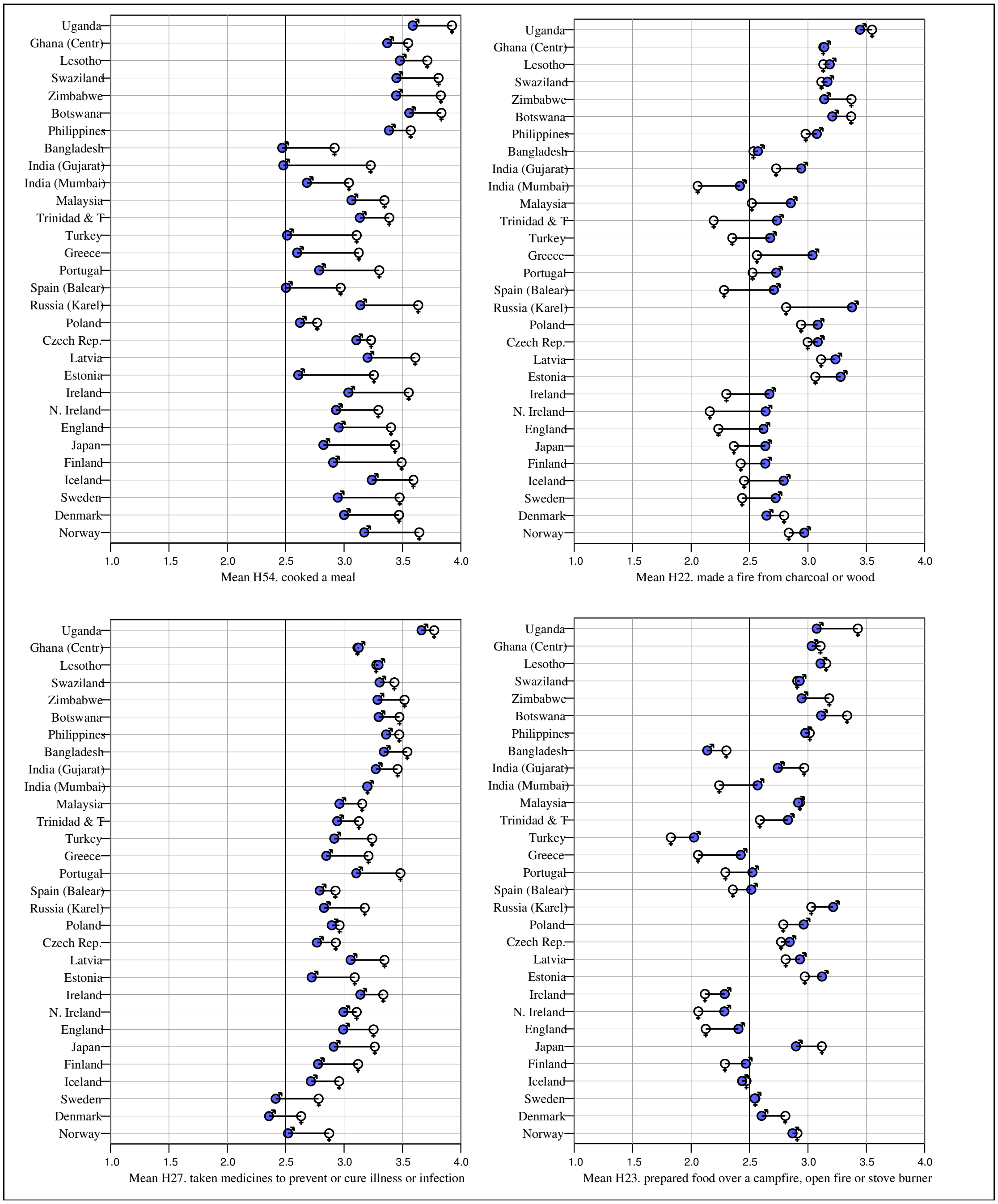

Figure 12-1. Illustrative examples of the pupils' out-of-school experiences across countries. See caption of figure 7-5 for diagram explanations.

12.3 Discussion

12.3.1 Boys' and girls' out-of-school experiences

The ten most frequent experiences in activities had some similarities among boys and girls. This confirms a finding from the SAS study that showed that boys and girls appeared to have similar outside school activities in the developing countries (Sjøberg, 2000b, 2002a). A common interpretation is that boys tend to be more adventurous than girls and might have skills and experiences from those adventures which are relevant for science and technology education.

When we consider the ten top and ten least activities, it is noticeable that most of the experiences were a kind of shared experiences across gender. Both genders had been involved more in activities, such as cooking a meal; making a fire from charcoal or wood; preparing food over open fire or stove burner; experiencing illness and getting medical treatment; and also experiencing nature or science through books, magazine, films, and TV programmes. Furthermore, they had a lot of experiences in using measuring ruler, tape or stick to measure and planting seeds and watching them grow. Some of the above activities for which both boys and girls claimed to be involved most often, appear closer to the curriculum contents in physical and biological sciences.

For biological science, the activities which included cooking a meal; experiencing illness and getting medical treatment; planting seeds and watching them grow; experiencing nature or science through books, magazine, films, and TV programmes seem to be closer to some topics in biology. The pupils with such experiences (experiences are put in parenthesis and placed in front of a likely topic or topics) are likely to have a great advantage in learning about some topics in biology. These experiences could also be seen to relate to some of the list of topics under questions ACE of the ROSE questionnaire, such as 'what to eat to keep healthy and fit'-(cooking a meal). In the context of disease control, treatment and drug abuse may have links with topics such as 'how to control epidemics and diseases', 'sexually transmitted diseases and how to be protected against them’, ‘cancer, what we know and how we can treat it’, ‘how alcohol and tobacco might affect the body’, ‘how different narcotics might affect the body’-(experiencing illness and getting medical treatment). The context of animal behaviour might link to ‘animals in my area’, ‘animals in other parts of the world’-(experiencing nature or science through books, magazine, films, and TV programmes). A biology topic such as types of germination of seeds or conditions necessary for germination may also link to topics like ‘how plants grow and reproduce’, ‘how to improve the harvest in gardens and farms’-(planting seeds and watching them grow).

Some of the top ten outside of school experiences could be deemed closer to physical science topics that may have bearing on some of the topics presented in questions ACE. A teacher, for example, could draw upon pupils’ experience in making a fire from charcoal or wood when teaching a topic that relate to sources of energy or types of fuels such as ‘new sources of energy from the sun, wind, tides and waves’. Preparing food over open fire or stove burner when treating a topic like ‘how energy can be saved or used in a more effective way’. Development of measurement skills is important in some practical laboratory task in science generally and physics in particular. Such skills could be developed outside of school as pupils play with tools such as measuring ruler, tape or stick to measure things around them.

The above experiences seemed to be the most popular. These experiences were popular among girls as well as boys. These activities can be seen in context of topics as belonging to the traditional sciences in particular biological science and can be presented in science curriculum. Some of the science topics that have been associated with the above activities also appeared on both girls’ and boys’ lists of most popular topics they would wish to learn about (see section 7.4.1). With such knowledge of the extracurricular experiences, teachers can cite things or experiences that are fair to all groups of young learners.

We also recognise that there were other out-of-school activities, which did not appear common on both lists of the top ten of the most popular activities for Ghanaian girls and boys in this study, which needs commenting on. The boys in general had more experiences in these areas such as the use of tools like a saw, screwdriver or hammer and also in an activity that involved the opening of a device, such as radio, watch, computer, telephone to find out how it works. Girls, on the other hand, dominated in activities that included collecting edible berries, fruits, mushrooms or plants and had also experienced being in a hospital as a patient. Such gender differences in interest in the above activities were also reported in other studies that made use of the ROSE questionnaire in their studies (see Lavonen *et al*., 2005; Jones *et al*., 2000).

It can be seen that the activities of the boys, such as those above, were more close to some topics in physical science and that of the girls are closer to topics in the biological science. For example, tools like a saw, screwdriver or hammer are devices or tools that are likely to be considered under the study of simple machines or levers in mechanics. An activity that involves the opening of a device, such as radio, watch, computer, telephone to find out how it works might better be described as an activity in the context of the study of electronics and electricity. The boys' most popular activities appeared to connect with some of the science topics (ACE items) for which boys had expressed higher interest than girls to learn about, which were also at statistically significant differences at p-value less than 0.05. Such topics are 'how things like radios and television work' and 'how to use and repair everyday electrical and mechanical equipment'. Girls' frequently involved activities that might be seen to be closer to biological science were experiences in collecting edible berries, fruits, mushrooms or plants and being in a hospital as a patient. Citing an outside of school experience in collecting edible berries, fruits, mushrooms or plants may be appropriate when treating topics such as: types of fruits, dispersal of fruits and might also be linked to girls' topic of interest like 'symmetries and patterns in leaves and flowers (see section 7.5.2).

The above top ten out-of-school experiences that had been reported by pupils in this study are not very surprising. They support a number of studies which confirmed general statements about the interest profiles of girls and boys in different content and context areas of science. These studies also showed that boys continue to have more extracurricular experiences that are related to the physical sciences than girls, whereas girls had more experiences than boys in biology (Lavonen *et al*., 2005; Jones *et al*., 2000; Sjøberg, 2002a; 2000b; Baker and Leary, 1995; Kahle and Lake 1983). This also confirms the finding of Sjøberg's study which revealed that there are systematic differences between girls' and boys' prior experiences (Sjøberg, 2002a). There may be several reasons for these differences, but Baker and Leary (1995) have noted that girls prefer biological sciences to physical sciences because they view biological sciences as areas where they can give help or care more for people, animals, or the earth.

The nature of the most of the boys' experiences appeared to reveal that boys tended to have a greater advantage in learning physics concepts. However, when we consider the girls' list of the most popular topics of interest they wished to learn, it was found that the majority of such topics matched those of the boys. This may imply that when girls are exposed to more frequent and early out of school time experiences, their achievement and interest in the physical sciences might be enhanced as they continue in their education. This is in line with the findings of Hyde and Jaffee (1998) and Jones *et al* (2000).

The pupils' out-of-school experiences indicated that many of the ten least frequent extracurricular activities of boys were similar to those of the girls. Ghanaian male and female pupils in the sample seldom involved in activities like 'charged a car battery', 'sorted garbage for recycling or for appropriate disposal', 'participated in hunting', 'used an air gun or rifle', 'used a windmill, watermill and waterwheel' and 'used binoculars'. The lack of interest in these activities for both genders is, however, not always clear and easy to comment on. For all these activities, there are strong relationships with science content put in different context in both biological and physical sciences. The reason behind such lack of interest could be that the least frequent activities tend to be uncommon occurrence in the Ghanaian society. This may imply that it will not be appropriate for teachers to expose pupils to new topics by linking to unpopular activities that pupils had indicated. These items provide irrelevant experiences in a science class in Ghana. It therefore becomes valuable for a teacher to gain an insight into kinds of extracurricular experiences which are likely to exist among young learners that learning new concepts and skills in science can be linked with to enhance understanding.

12.3.2 Gender differences in out-of-school experiences

There were many gender differences in the outside of school activities. It is noteworthy to observe that among the activities that showed statistically significant gender differences, boys were seen to enjoy all the extracurricular experiences that appeared to relate to the physical sciences. The three other experiences in favour of girls have aspects that may link to biology. Similar findings have been reported in other studies, which revealed that boys tend to have more experiences in the physical sciences and girls tend to have more experiences in the biological sciences. The overall impact of the difference between these outside of school time science experiences for boys and girls on their participation in science is still not fully understood (Clewell and Campbell, 2002).

The out-of-school activities for which girls in this study claimed they often involved themselves in, which came out to be statistically significant different from that of the boys are more of gender stereotypes. The typical girls' experiences appeared to imply that girls and their background of experience are not of great weight in school. This is because these activities that were attractive to the girls tend not to be part of the established science teaching curriculum. For example, girls were more attracted to activities such as: cooking a meal; knitting, weaving; and baking bread, pastry, cake. At best they may be cited when treating topics like sources of heat, expansion and probably when discussing ‘what to eat to keep healthy and fit’, which is more of biological oriented experience.

For all the activities that boys claimed to have been involved in more than girls appear to relate strongly with physical science contents put in different contexts. I will examine or classify the likely context area for which the boys’ activities could fit in relation to the study of school science. The context areas in school science where the following boys’ prior experiences could fit are in parenthesis. For example, ‘making a bow and arrow, slingshot, catapult or boomerang’ (tension, resulting from stretching something); ‘using tools like a saw, screwdriver or hammer’ (classes of levers); ‘using a wheelbarrow’ (simple machines, moments, classes of levers); ‘changing or fixing electric bulbs or fuses’ (electricity and house electrical circuit); ‘mending a bicycle tube’ (air pressure); ‘using a crowbar’ (simple machines, classes of levers, moments); ‘making an instrument like a flute or drum from natural materials (sound waves, sound produced by different musical instrument and tension); ‘opening a device such as radio, watch, computer and telephone to find out how it works’ (electronics or the use of electricity for information processing); ‘making a model such as toy plane or boat’ (buoyancy) and ‘charging a car battery’ (electricity, sources of energy, transformation of energy).

We note that the activities the boys were often involved in can be seen to be typical of boys. This appears to be the case, because according to Schwedes (2005), in a family, boys are usually encouraged by parents in using tools such as hammer, saw, file or electric drill while girls are warned not to use such tools in order not to hurt themselves. From the foregoing, it seems boys’ activities appear more often to have relevance for science learning. This may mean that when girls enter school, they do so with less opportunity than boys to practice in technical and scientific fields. Girls’ knowledge in science has a much smaller experience based. As a result, girls continue to be disadvantaged in an attempt to learn science. So when teachers rely on equal dispensation for boys and girls, boys will appear to have better chance than girls in understanding science. Boys are also likely to dominate classroom discussion and even challenge the teacher on some issues in science than to work together. That is why it is important for the teacher to know what kind of experiences pupils have outside school.

It has already been mentioned that the overall impact of the difference between these out-of-school time science experiences for genders on their participation in science is still not fully understood. It also becomes difficult to fully explain why some girls are successful in science. This observed phenomenon may be in the natural science itself and the image of science we continuously propagate as science educators. Female pupils' attitudes towards science could also be as a result of some experience or perception about the subject and this might be one reason why few girls excel in science. Nevertheless, I take the view that if girls would be given the same opportunities to learn science as boys, they could perform as well as boys.

12.3.3 Urban and rural school pupils' out-of-school experiences

Most of the ten extracurricular activities, which both urban and rural pupils claimed they frequently involved in are similar with that of the boys and girls in this study. The perceived relevance of these activities to the study of school science has been dealt with in the previous discussion sections on the genders' and differences in genders' outside of school time experiences. Nevertheless, few of the activities which appeared differently on their list of the often done experiences will receive comments.

The majority of the urban pupils deemed the following activities different from that of rural pupils as among their list of the ten most popular activities. The activities are using a compass to find direction; opening a device (radio, watch, computer and telephone) to find out how it works and reading a map to find a way (see table 12-4). Considering that their choice is a true reflection of the activities they claimed to involve in, then the urban pupils' activities of using a compass to find direction and reading a map to find a way become unclear and difficult to interpret. This is so, unless a number of urban school pupils in this study are members of boys and girls scout club where compass use and map reading are likely to be taught. However, such experiences could be relevant or cited when there is a classroom discussion on a physics topic like notions of motion with reference to basic vectors such as displacement and velocity.

In the Ghanaian society, collecting edible berries, fruits, mushrooms or plants; planting seeds and watching them grow and walking while balancing an object on the head are activities that are most likely to be associated with the rural community (see table 12-4). Those experiences tend to be among the ten top activities of the rural school pupils. The experience in walking while balancing an object on the head can be seen as belonging to a concept in the traditional physics. The concept, which rural pupils could be exposed to that can be linked to the activity of walking while balancing an object on the head is 'balanced forces or equilibrium with several forces'. Other activities in favour of the rural pupils have been discussed when the genders' activities were considered.

Four of the ten least performed activities were common for both the urban and rural pupils; and also on the boys' and girls' lists of the least popular activities. Those activities involved charging a car battery; using a windmill, watermill and waterwheel; using binoculars and using an air gun or rifle. Most of these activities are not common in both urban and rural communities in Ghana. The activities among the ten least outside of school time experiences which differentiated urban pupils from rural pupils appeared to be locally based activities. The same activities are not likely to be available in both urban and rural communities. The activities for which urban pupils claimed they do not have experience in them are typically found in rural communities, for example, weaving; making a bow and arrow, slingshot, catapult or boomerang; participating in fishing and hunting (see table 12-5). However, fishing remains the mainstay occupation of majority of male adults in communities along the coast of Ghana.

On the other hand, most of the activities, which were not popular among the majority of the rural pupils, could be classified as experiences in using information and communication technology (ICT). ICT tools are often found in most of the urban communities (see table 12-5). Many of the rural communities in Ghana lack the requisite facilities to handle such activities. It is therefore, difficult to relate rural pupils' lack of experience to a possible lack of interest in the use of ICT. However, whatever the way one interprets this finding, majority of the rural pupils will continue to be disadvantaged when there is opportunity to learn about modern technology at school.

In short, it appears the differences between urban and rural pupils as they engage in school science are more institutionalized than due to attitudes. Hence it appears gender differences come out distinctively clearer than that of the geographical backgrounds, which is a strong indication that a debate over equity in the science curriculum should focus more on the gender differences and less on other aspects, such as geographical backgrounds in a particular culture.

12.3.4 Ghanaian pupils' out-of-school experiences as compared to that of pupils from other countries

Based on the figure 12-1, it appears the responses of pupils to the out-of-school experiences for the four items do not follow a clear pattern when related to the level of the development of a country. It was evident in pupils' relationships with school science and technology. However, these activities for which the majority of both genders had involved in might be closely related to the curriculum contents in the physical and biological sciences in the various countries. The relationships of some of the out-of-school activities with the likely science curriculum contents and context have been dealt with in more detail in the early sections of this chapter. Teachers citing them appropriately in their science lessons when introducing new topics and concepts could enhance understanding and hence sustain pupils' interests in school science and perhaps motivate them to pursue further studies in the science and technology-related courses.

Conclusion

Most of the experiences were a kind of shared experiences across gender. Both genders were involved in activities such as cooking a meal, making a fire from charcoal or wood, preparing food over open fire or stove burner, experiencing illness and getting medical treatment; and also experiencing nature or science through books, magazine, films, and TV programmes. Furthermore, they had a lot of experiences in using measuring ruler, tape or stick to measure and planting seeds and watching them grow. Some of the above activities for which both boys and girls claimed to be involved in most often, appeared closer to the curriculum contents in physical and biological sciences. Some of the top ten outside of school time experiences have been classified to be closer to physical or biological science topics that have bearing on some of the topics presented in questions ACE. A teacher, for example, could draw upon these experiences when pupils are exposed to new concepts and topics. The out-of-school activities for which girls in this study claimed they often involve themselves in were more of gender stereotypes. For example, girls were attracted to activities such as cooking a meal, knitting and weaving; and baking bread, pastry and cake. The typical girls' experiences confirm that girls and their background of experience are not of great weight in school. This is because these activities that were attractive to the girls tended not to be part of the established science teaching curriculum.

For boys, the activities related strongly with physical science contents put in different contexts. The activities are: making a bow and arrow, slingshot, catapult or boomerang; using tools like a saw, screwdriver or hammer; using a wheelbarrow; changing or fixing electric bulbs or fuses; mending a bicycle tube; using a crowbar; making an instrument like a flute or drum from natural materials; opening a device such as radio, watch, computer and telephone to find out how it works; making a model such as toy plane or boat and charging a car battery.

The activities, such as using a compass to find direction; opening a device (radio, watch, computer and telephone) to find out how it works and reading a map to find a way, were more popular with the urban pupils whiles experiences in collecting edible berries, fruits, mushrooms or plants; planting seeds and watching them grow; and walking while balancing an object on the head were in favour of the rural school pupils.

In the following chapter I shall highlight on some of the views about the ROSE questionnaire shared by pupils during the interview with them. This approach was meant to validate the data quality. Answers given by the respondents during the interview were tape recorded and later transcribed. The findings from the interview were also discussed.

13. PUPILS' VIEWS ABOUT THE ROSE INSTRUMENT THROUGH INTERVIEWS

13.1 Introduction

The basic principle behind qualitative interviewing is to present a framework within which respondents can articulate their understandings about an object in their own terms (Patton, 1990). In line with the overall objective of the ROSE project, the ROSE instrument is meant to be used in every part of the world. And in each culture, there is a possibility that there will be words, phrases and even context in the instrument that may seem strange or unfamiliar to the pupils. This is because there are large differences in experience and interest between children from different countries. It is also possible that some of the pupils will find some aspects of the questionnaire difficult to understand and this may lead to cursory responses. Some of the words and phrases that appeared difficult to some of the Ghanaian pupils came to the fore during the pre-testing of the instrument with some of the pupils in the study area in Ghana (see section 5.6.2).

In order to assess the respondents' understanding of the questionnaire items, I interviewed a few of them. The aim was to establish a better understanding of the views they had expressed about some of the statements in the questionnaire and to question the pupils about the underlying ideas about their views. There are several circumstances in which a qualitative research interview is most appropriate. In this present circumstance, a quantitative study has been carried out and qualitative data were needed to validate particular measures, illuminate and illustrate the meaning of some of the findings that emerged from the pupils' responses to the ROSE questionnaire. Unlike quantitative approach to attitudinal studies, qualitative approach seeks to explore in some depth pupils views and their rational (Osborne and Collins, 2001).

13.2 Aims of the interview

The interview component of this study aimed at articulating the general views the respondents hold about the questionnaire. The aim centred on:

- the nature and content of the ROSE questionnaire;
- the aspects of the questionnaire they like or find interesting;
- the aspects of the questionnaire they dislike or find uninteresting; and
- the rationale behind their reactions.

Thus the general aim of adopting a qualitative-based approach was to elicit different responses on strengths, weaknesses, dislikes, likes and reasons attached to their experiences with the questionnaire.

13.3 Interview question focus

An interview question is seen as a stimulus that aims at creating or generating a response from a person being interviewed; and this makes question wording one of the most important elements which determines how the interviewee will respond (Patton, 1990). In this study, the interview questions posed to pupils were modified and the sequence varied to conform to the questions set below to suit the needs of an individual interviewee. The question format adopted permitted pupils being interviewed to take whatever direction and use whatever words they wanted in order to present what they would want to say.

The interview questions mainly focused on what pupils think or feel, what they like or do not like and why that behaviour with regard to their experiences with the ROSE questionnaire. The following questions guided the interview:

- What is your own personal view about the nature and content of the questionnaire?
- Which areas of the questionnaire did interest you the more?
- What are some of the things you don’t like about the questionnaire?
- How would you explain the reasons for your experience?

These are questions aimed at understanding the emotional responses of pupils to their experiences and thoughts.

13.4 Methodology of the interview

The method adopted to elicit their views was the use of one-to-one (individual) or face-to-face interviews approach with pupils. This is one of the approaches to the gathering of qualitative data and has the advantage, among others, of providing wide-ranging data. However, it is exceptionally time consuming to collect a representative sample of views (Osborne and Collins, 2001). In many developing countries, it is further constrained by financial and educational logistics. Nevertheless, the information gathered is likely to provide a true reflection of individual views.

In this interview the participants were selected to reflect gender and geographical location. To have time and logistics advantages, I interviewed only eight pupils. As stated earlier in section 5.9, the pupils were selected from four (4) schools (two schools each from urban and rural areas respectively). For each school a girl and a boy were chosen.

A semi-structured approach was adopted. This approach allows an individual being interviewed much more flexibility of response (Miller and Crabtree, 1999) and is widely used in combination with other methods. According to Miller and Crabtree, in semi-structured interview, questions are predetermined. The order can be modified based upon the interviewer's perception of what seems more appropriate. Question wording can be changed and explanation given. Furthermore, particular questions which seem inappropriate with a particular interviewee can be omitted, or additional ones included. Unlike the semi-structured interview, the standardized open-ended interview is used when it is essential to reduce variation in the question posed to interviewees (Patton, 1990). According to Patton, it consists of a set of questions carefully worded and arranged with the intention of taking each interviewee through the same sequence and asking each interviewee the same questions with essentially the same words.

These two forms of approaches to interviews have their own advantages and disadvantages, but I will not pursue these aspects of the two approaches since it is not the focus of this study. A standardized open-ended approach enables the interviewer to obtain a set of information in a similar form from each interviewee and also makes data analysis easier (Patton, 1990). However, in my view, it may rather be difficult to use this approach to gather information when the interviewees appear to have different levels of competence in English language. I mentioned in section 5.6.2 that some of the pupils in the sample have limited ability in English. The English language factor necessitated the use of the semi-structured approach in the interviews in this study. With this I was able to alter question wording when it became appropriate.

The interviews were conducted from February to March in the year 2004. In view of the fact that there was elapsed time after the questionnaire was administered, I had to introduce myself once again and also to explain to them the purpose of the interview. I also assured them of the confidentiality of their responses and their identities, and sought their permission to tape the views they would express. Interviewing individuals is time-consuming as against focus-group interview (Osborne and Collins, 2001). In this study, the actual interview session varied in length; however, each session lasted between 20-30 minutes. The responses to the questions were captured by taping the interview. After the recorded interview, I checked the tape to make sure it was functioning properly and which were later transcribed. I ended the interview with words of appreciation for helping me with information and giving up their time.

13.4.1 Transcription and Analysis

The standardized survey questionnaire was the primary source of data collection technique and the interview was only an approach in the study to validate the findings. As an alternative to full transcription, I was selective in picking only relevant passages. Only those quotations that were particularly relevant to data analysis and reporting were transcribed, since there were deliberate introduction of dichotomous response questions (question suggesting a *yes* or *no* answer). Those dichotomous response questions were included in an initial thought of trying to defuse any tension that might have built up and also to build confidence in the interviewees. Together with these reasons, was that the resources were not sufficient to permit full transcriptions.

The main focus for the qualitative data was to supplement and illustrate the quantitative data obtained from the survey. This small amount of qualitative data which are used as an addition within a largely quantitative fixed design study will not justify detailed and complex analysis (Robson, 2002). However, according to Robson, when the qualitative data generated form the sole aspect of the study, then serious and detailed attention needs to be given to the principles of their analysis. This meant that the data from the qualitative approach in this study, did not receive any rigorous analysis through the use of a special computer software package. It rather sought to develop a deeper understanding of not only what pupils think but why they think it. In the next section, I report some of the data and the findings from the interviews with pupils.

13.5 Results and discussion

13.5.1 Results

The answers of some of the selected respondents during the interview were transcribed and summarized around four themes connecting some aspects of the ROSE questionnaire, which are:

- pupils' perceptions of the nature and content of the questionnaire;
- interesting aspects of the questionnaire to pupils;
- uninteresting aspects of the questionnaire to pupils; and
- reasons pupils hold for their views.

These are the themes on which the interpretation of the interview data of the selected interviewees was based. This study does not include the entire interview data. Those that are outlined in this section do present the most important rudiments of what the pupils had to say. Hence, my use of them to validate or otherwise the quantitative data, which were gathered through the use of the ROSE questionnaire should be tenable. My aim in analyzing the interview data is to account for events, rather than to document their sequence; with an overall view consisting of data display and conclusion drawing. I will begin this with what the pupils in the two urban schools had to say and continue with that of pupils in the rural schools.

Answers of pupils from the urban schools:

> **Boy 1 from urban school 1**: The questionnaire has too many questions…but a greater number of them were easy to understand…because you explained the words that are difficult to us…I can say that I believe in my answers. The questions were interesting …I found some statements new and I became interested to know more about the words…but at home I see animal that is born…for example a goat and make fire from charcoal.
>
> **Girl 1 from urban school 1**: Yes…I felt at ease when responding to the questions…because…I understood when you gave us meaning of words. Questions on my future job were easy for me because the types of jobs are easy to understand…a job I am happy about is making, designing or inverting something…we can still find solutions to our environmental problems, this is important to me…because I am always worried about the environment getting bad…because people throw rubbish anywhere and people cut down tree anyhow.
>
> **Boy 2 from urban school 2**: I have interest in the computer and mobile phone…I do not have my own mobile phone…I use somebody's mobile phone on one occasion…and there is no computer at home or school…but I often play computer games...I go to the internet café to play the games and pay for it using part of my pocket money…my friends teach me how to use dictionary on the computer at café.

Girl 2 from urban school 2: I want to learn about cloning of animals…because I only know that male and female have to meet to produce young ones. I disagree that school science is interesting and easy for me to learn…because when they [teachers] teach me I do not understand some of the topics in general science. They [teachers] must exercise patience when teaching and…also must pay attention to some of us…and I would not like to become a scientist.

Answers of pupils from the rural schools

Boy 1 from rural school 1: Questions are too many…some of the questions were difficult to understand…no!no!no!…when you explained the difficult ones I was able to choose what I wanted…I did not choose anything (an option) from those I did not understand…Yes!...I left them blank, for example, 'Light around us that we can not see' and 'black holes and cloning of animals' (items most difficult to answer)…Yes! But sir! I did not understand your explanation. Sir, we use light to see, so which light does not make us to see?...Very interesting…I want to know more about them.

Boy 2 from rural school 2: Yes! I agree that school science has opened my eyes to new and exciting jobs…the things that I learn in science at school will be helpful in my everyday life…but I disagree that everybody should learn science…because some of my friends always say they will not learn science because it is too difficult. They say business is good because they will get money.

Girl 1 from rural school 1: I thought it was an examination...we have just finished our trial examination…so I was thinking it was another examination…I have known that you can learn about so many things (from the questionnaire)…there are many things that interest me…, for example, how animals use their colour to hide or attract…how the computer works…why we dream while we are sleeping. Sometimes, I wonder how we (human beings) can do that, so I want to know more…how they (animals) change colour…for example, there is one animal which changes colour…but I have forgotten…it is like a lizard (chameleon).

> **Girl 2 from rural school 2**: Yes! I agree that science and technology will find cures for diseases such as HIV/AIDS…because I know that science people (scientists) learn about out diseases.

13.5.2 Discussion

The discussion is done along the themes that connect some aspects of the ROSE questionnaire, which emerged during the interviews and as stated in the section 13.5.2 above. However, the fourth theme regarding the rationale behind their perceptions of the ROSE questionnaire will be incorporated in the first three themes.

Pupils' perceptions of the nature and content of the questionnaire

When we turn to the nature and content of the ROSE questionnaire, it appears all pupils in the sample, probably more boys than girls in both the urban and rural schools considered the questionnaire to be too long. This is exemplified by the comment made by boy 1 from urban school 1: *The questionnaire has too many questions* and in addition, by boy 1 from rural school 1 who commented that *some of the questions were too difficult to understand.* There was girl 1 from rural school 1 who at the initial stage of the exercise considered it as a part of their trial examination, probably because they had just completed a trial examination. This attests to my earlier observation that some of the pupils were physically shaken and nervous as they started answering the questionnaire (see section 5.7.2).

However, the most interesting aspect of their comments about the questionnaire was that it was easy when responding to the items. The reason they found the questionnaire easy to answer was well articulated by both genders in both rural and urban schools. They both confirmed that it became somehow easier as a result of explanations given; and because of that they were able to choose their appropriate options. According to boy 1 in rural school 1, he did not select any answer where there was no understanding. Hence they tended to believe in their choice, which was expressed by boy 1 in urban school 1.

Another aspect of the questionnaire which was easy to answer, according to the girl 1 from urban school 1 was when responding to questions on ‘my future potential occupation or job’. Her reason was that the job qualities are easy to understand.

The finding appears to demonstrate that the pupils’ responses to the items were the true reflections of their own thinking and perhaps, they might not have completed the questionnaire in a cursory manner. The word, ‘explanation’ has been a singular reason that made their answering of the questionnaire easier. Such a reason which was advanced by pupils would appear to be summarized by the view that cross cultural surveys may have a varying importance, but the respondents in such studies, most often will need some sorts of clarifications of some of the contents of survey questionnaires. This is necessary, especially, in developing countries, where English language skills continue to be one of the hindrances to good quality education. As already stated in section 6.5.2, Ghana, as an example, has been cited in a World Bank report that, the problem with the language of instruction is one of the major causes of poor teaching and learning outcomes (World Bank, 1996).

However, clarifications of survey questionnaire items would not be appropriate when the survey (for example, TIMSS) focus is on performance in the cognitive domain, where the performance of all pupils is also described in terms of international benchmarks. Therefore, it may be suggested that the poor performance of some African countries like, Ghana, in TIMSS study could be partly due to lack of competence in English language.

Interesting aspects of the questionnaire

The interesting aspects of the questionnaire to pupils, which were elaborated on during the interviews, included the following: According to some of them, they found some of the statements new (probably unfamiliar statements or science topics). As such they became interested to know more about them. For example, boy 1 in urban school 1 stated that at home he had seen a goat been born before. Perhaps, as a result of mating and probably does not know other possible means of producing offspring and may want to learn more about other means like, cloning of animals. A similar interest was expressed clearly by girl 2 in urban school 2 in the statement: *I want to learn about cloning of animals…because I only know that male and female have to meet to produce young ones.*

Another interest in unfamiliar science topics that some of the pupils would want to know more about, which did not appear on the list of the top ten of the most popular science topics for all groups of pupils. However, they emerged during the interviews which were 'how animals use colours to hide or attract' 'why we dream while we are sleeping' (see tables 7-1 and 7-4). I made mentioned in section 7.3, paragraph 3, that a mean value above or below 2.5 does not imply that all pupils may be interested or disinterested in a statement, but the majority are. It is likely that few of the pupils might have indicated their interests in these topics, though these items appeared typically unpopular among the majority of the pupils. This implies that inclusion of some of these topics in the science curriculum may not be appropriate. However, their interest to know more appears to be based on 'curiosity' or 'wonder'. This is elaborated in the statement of girl 1 in rural school 1 that s*ometimes I wonder how they (animals) can do that, so I want to know more…how they (animals) change colour…for example, there is one animal who changes colour…but I have forgotten…it is like a lizard (chameleon).*

Both boys and girls from the two geographical backgrounds expressed interest in the computer and mobile phone and would want to know how these devices work. This sentiment about interest in these modern technological devices came from both girl 1 in rural school 1 and boy 2 from urban school 2. It appears amongst all pupils, there is a general interest in science that includes some aspects of modern technology. This interest also featured high on the list of the top ten of most popular topics for all pupils through the response to the questionnaire items on some science topics of interest (see tables 7-1 and 7-4).

It was also revealed during the interviews that pupils in this study had a general concern for the environment and believed that the environment can be damaged through human activity. However, they appeared to show optimism about the environment. The following comments from girl 1 in urban school 1 emphasizes this point: *We can still find solutions to our environmental problem, this is important to me…because I am always worried about the environment getting bad…because people throw rubbish anywhere and people cut down tree anyhow*. Such comments appear to support the concerns shown by the majority of the pupils for the environment when the responses on their views regarding environmental challenges were analyzed (refer to sections 8.3.1 and 8.3.2).

Despite the pupils' general positive view of the value of science, which was revealed through the responses to questionnaire on how they relate to school science (see sections 9.3.1 and 9.3.3); girls, in contrast, did not comment on the importance of science either to themselves or to their everyday lives. They rather made negative comments about their school science as a difficult subject. During the interview, boy 2 in rural school 2 elaborated on the importance of science to himself in his everyday life but,emphasised the fact that some of his colleagues find science very difficult. He said: *Yes! I agree that school science has opened my eyes to new and exciting jobs… the things that I learn in science at school will be helpful in my everyday life…but I disagree that everybody should learn science…because some of my friends always say they will not learn science because it is too difficult. They say business is good because they will get money.*

Another distinction between the boys and girls was that it was girl 2 in rural school 2 who offered a comment on the role of science and technology, though, all responses coming from the questionnaire indicated that they held a positive view of many aspects of science and technology in society (see for instance, sections 10.3.1 and 10.3.3). She was optimistic that through science and technology, scientists will find cure for diseases, in particular, HIV/AIDS. The optimism was illustrated by her comment: *Yes! I agree that S&T will find cure for diseases such as HIV/AIDS …because I know that science people (scientists) learn about diseases.* This comment seems to be in line with the expectations pupils hold for science and technology, as well as scientists, which were listed as the various aspects of the role they expect of science and technology to play in society. It also accords with the findings in this study, which indicated that the majority of pupils were more interested in learning about HIV/AIDS and how to control it.

Their future job characteristics appeared to be dominated more with occupation that will earn them a lot of money and perhaps, their belief that they were not likely to realize this hope through engaging in school science; and also when science had been perceived to be difficult as a school subject by some of the pupils. This was clearly commented on by the boy 2 in rural school 2 and according to him, some of his colleagues have indicated their intention to go into business, which to them, will earn a lot of money. The type of business they crave for is not very clear, but what probably they would wish as they relate to school science is to expose them to science related occupations that are likely to earn them a lot of money. The desire for a future job, which has the possibility of earning a lot of money, also appeared high on their job priority list, when they responded to the ROSE questionnaire. Girl 1 in urban school 1 also expressed an interest in a future job which involves making, designing or inventing something. At the JSS level and also in Ghana, the respondents are likely to associate 'making, designing or inventing something' with fashion and dressmaking and as such it has a more traditional gender bias in favour of girls.

Very little was said about outside school time experiences. It seemed boys had more opportunity to engage in the use of computer, especially to play computer games, though it was not often. An access to computer was most often at internet café. Occasional experiences with computer and mobile phone was reported in a comment given by boy 2 from urban school 2: *….I used somebody's mobile* *phone on one occasion….and there is no computer at home or school…but I often play computer games...I go to internet café to play the games and pay for it using part of my pocket money…my friends teach me how to use dictionary on computer at café.* The boy's comment about inaccessibility to computer at school and home supports an earlier finding in which Anamuah-Mensah and colleagues looking at information on classroom characteristics in the TIMSS 2003 study indicated that in Ghana, the majority of Ghanaian pupils lack access to computers (Anamuah-Mensah *et al.,* 2004).

Uninteresting aspects of the questionnaire to pupils

However, despite the pupils' general positive view of the value of science, as they showed in their responses to questionnaire items on their relationships with school science, there were other aspects of school science that they found uninteresting and probably difficult (see section 9.2.2). A girl, amongst those who were interviewed made more negative comments about school science than boys. The comments, which were made by girl 2 from urban school 2 about school science, are*: I want to learn about cloning of animals…because I only know that male and female produce baby… I disagree that school science is interesting and easy for me to learn…because when they [teacher] teach me I do not understand some of the topics in the general science. They [teachers] must exercise patience when teaching and…also must pay attention to some of us… and I would not like to become a scientist.* The comments are likely to suggest that the school science lacked appeal for some of the pupils, especially, girls. Not only did they express difficulty in school science, but they also failed to recognize teacher's effort in the science class and also found the lack of teacher's attention to them, which could be demoralizing.

Though the focus of this study is not on the teacher, the role a teacher plays in stimulating and maintaining pupils' interest in a subject is an important factor. The girl, in particular, was not happy with the approaches adopted by her teacher in teaching general science. The method of presentation of science lesson had not been appealing enough and this might be the concerns of a number of girls in science classes in the sample area. The girls need attention; patience and encouragement from the teacher as it was made known by a girl during the interviews .Such needed qualities of the teacher are likely to enhance understanding. Lack of these qualities on the part of the teacher is also likely to discourage girls from engaging in further courses in the sciences. Perhaps, this might be one of the many causes for the few female scientists in Africa, as the same girl indicated her unwillingliness to become a scientist. This comment appears to be in line with the responses to the questionnaire from more girls than boys that they were not enthusiastic about becoming scientists as they engage in school science (see section 9.3.2, paragraph 2).

However, despite the inability on the part of the girl to understand some topics in general science, the Ghanaian girl was interested in learning more about some aspects of science, for instance, cloning of animals, which featured in her comments. The interest to know more about cloning of animals shown by this girl during the interview does not accord with the findings of the majority of the pupils from ‘what pupils would want to learn about in science’. The responses from the majority of pupils on the interest in learning about cloning of animals achieved a low mean value, which was less than 2.5 for all groups of pupils in the sample area (see tables 7-2 and 7-5). The reason given by the girl in her comments appeared to indicate a good knowledge in ‘sex and reproduction’. She said: *I only know that male and female have to meet to produce young ones.*

Based on the view expressed by the girl on the teacher’s pedagogical practices of school science, it is suggestive that pupils value individual attention from a teacher. A teacher must be patient enough to explain difficulties when they arise. This may sustain the interest of pupils, in particular girls, to continue with science. This suggestion supports the work of Osborne and Collins (2001), they state that ‘the interest of pupils in continuing science was raised by teachers who devoted time during lessons to the clarification of content’ (p. 459).

The findings from the interviews are conclusive evidence to indicate that the pupils' responses to the ROSE questionnaire were a true reflection of what relevant science education means to them, though there may be some exceptions to the expectations of the majority of pupils towards school science. Therefore, the inclusion and the emphasis of such expectations in the science curriculum are unquestioned.

14. IMPLICATIONS FOR SCIENCE CURRICULUM: CONCLUSIONS AND RECOMMENDATIONS

14.1 Introduction

> *When young girls and boys entering puberty lack the same science experiences and begin to encounter their peer's stereo-typical beliefs about areas of study, the potential for the gender (as well as urban/rural) gaps to widen is enormous (Jones et al., 2001:187).*

As mentioned earlier, the general underlying assumption of the ROSE project is that there are interesting cultural differences and similarities in pupils' interests, priorities, future expectations, experiences, which are of relevance to teaching and learning of science at school. And among the aims of the ROSE project is to explore some affective qualities of science teaching and learning in order to provoke some thoughts and stimulate some discussions about science curricula in various cultural and societal contexts.

The findings of this study, when taken collectively, provide powerful implications for reframing of the science curriculum at the basic level. There is therefore a clear message to curriculum designers in this regard. If all the pupils were making what might be called the right decision in expressing their views then we cannot exclude the voice of the pupils themselves in promoting quality science education in Ghana.

In this last chapter, the implications of these collective findings and the insights they offer for school science curriculum are discussed, summary and conclusions of and recommendations arising from this study are provided.

14.2 Implications for science curriculum

The pursued objectives of this study are to give fresh impetus to the debate on science curriculum reforms for the JSS level in order to serve the needs of pupils. In general, the voice of pupils is clearly missing in the constitutive voice in the science curriculum formulation. This implies that only the views of scientists, science educators and curriculum policy makers are assumed or perceived to be important in determining those aspects of science that pupils are expected to study. But there are some aspects of science both contextual and content-wise, which pupils perceive to be relevant to their everyday lives, such as health, career choice, eradication of diseases and epidemics and waste management. What learners regarded as relevant and how they have responded to this relevance in this study will require a type of science curriculum that will facilitate the delivery of relevant science, including the relevance of context, purpose and method.

It is argued that if children are not comfortable or happy they will not learn, irrespective of how well pedagogical practices are designed. Despite the claim that pupils will feel good at the expense of becoming educated, the choice by pupils or students to study science may be for various reasons, such as being both interesting and useful for job, to mention a few. Therefore without any relevance in what is learnt, sustaining the interest will be difficult, if not impossible. Hence, a science curriculum whose content is partly determined, or at least influenced by the expressed needs and interests of the child, may produce a curriculum more relevant to the child. In this time of increasing pupil diversity and higher standards, I believe it is the children we teach who must remain in the forefront of planning, teaching, assessment, and accountability. Interestingly, it has been shown by many studies, already cited in this study, that rewriting the science curriculum based on what we know about pupils' interests may change their attitudes to, and learning of the subject.

Traditionally, science has been taught as though all students could, and should, become practicing scientists. However, very few students in science classes will actually end up being scientists, but all have a right to a good science education. Students or pupils who choose science or professional science appear to represent less than the percentage envisaged by Ghana as required by the Vision 2020 in the National Science Policy Document. The need now is an image of science that promotes teaching and a curriculum that is geared towards producing scientifically literate citizens. This means that curriculum's content should be directly applicable to everyday science-related problem solving. Hence any attempt to reconstruct science curriculum should be more of a context-driven science. This should be different in character from the 'pure science' which is presented by most school science courses.

The important goals of relevant science education are to recognize the perceived needs and interest of the learner, the needs of society in which science is embedded and prepare and equip learners for future occupation. Furthermore, it must relate more to social issues in order to promote interest in science.

Science education continues to be an education for science instead of an education about science. The science curriculum is mostly dominated by materials needed for the post-compulsory science related courses and the scientific establishment. As such, the constitutive voice in curriculum formulation, for long, has been through the agency of a wide range of professional bodies, including scientists and science educators, but excluded in this debate are the voices of pupils who are the direct beneficiaries of the curriculum (Osborne and Collins, 2001).

The growing imbalance between science as experienced by the public at large and the science which is taught at school has been part of an ongoing debate on the future of the science curriculum in Ghana (Anamuah-Mensah and Towse, 1995, cited in Towse *et al.*, 2005) and elsewhere (Millar and Osborne, 1998).

For long, there has been a general consensus among educators that each society has to construct their own science curricula to fit their own purposes for schooling. Furthermore, teaching should build on the interests and experiences of the child (Sjøberg, 2000b). With this, educational content is likely to fit into the personal or societal context of the child. In the light of such considerations, schooling becomes meaningful and relevant to the child. Different preferences may also indicate that different curricular emphasis may appeal to different groups of pupils. Unfortunately, children's perspectives have been ignored in much science education research.

It seems to me that an approach to the science curriculum which is based on insights from science education studies that draw partly on affective domains and feminist arenas can offer hope of a science education that is highly relevant to young peoples' lives. As science educators engage with pupils, I consider those pupils' views about the role and content of science should make a contribution to a project, such as the ROSE project, to review science curriculum. The affective learning experiences for students require a curriculum based on students' ideas and scientific understanding, allowing curriculum and instruction to be sequenced in a way that moves students towards scientific understanding (Driver *et al*., 1994).

For all pupils to appreciate, understand and benefit from the science they are expected to learn there is the need to accommodate their views in the construction of the curriculum. One way of achieving this, is by identifying those aspects of science that pupils appreciate, value and are relevant to their everyday lives and that of their community. Whilst canvassing for the pupils' views, it is also important to note that such views cannot be the sole determinant of the curriculum. However, I argue that it is better and makes sense to appreciate and recognize their contribution to the ongoing debate.

In the intended science curriculum, emphasis is placed on learners knowing basic science facts, understanding science concepts, learning about the nature of science and enquiry and writing explanations about what is observed and why what is observed happens. However, less emphasis is put on the science topics which motivate pupils to learn about them especially, their interest in learning about modern technologies, which have been reported by the pupils who took part in this study. The national curriculum contains policy statements about the use of computers in teaching. However, computers are not available to most pupils (Anamuah-Mensah *et al*., 2004).

It is important that school science education reflect this if it is to adequately prepare school leavers for a meaningful future to fully participate in social and economic development. More importantly, the current focus of interest on technological matters is of central interest to both boys and girls. Some change in content and the style of teaching to some extent, I believe, will lead to a significant increase in the choice of physical science by girls in particular.

Ghana needs more scientists and professionals in science and technology than ever. Implicitly, there is the need for such reworking of science curriculum which becomes even more significant in view of the fact that many studies have indicated that students consider some factors when decisions on career choice or path are being made. Notable among these studies is the study conducted by Lewis and Collins (2001), where they observed that those participants in their study, who altered their paths may have done so through their more recent choices as more relevant to their lives and long-term goals. And also having a more direct application or relevance, or as being more interesting.

However, attempting to rework the science curriculum according to the values and interests of pupils is not meant to *devalue* the high quality accepted science. School science could appear more meaningful to pupils when science curriculum considers to some extent, the pupils' values they hold for school science.

Rational planning and improvement of society through education need to be based on research evidence. The results and findings of this study are likely to inform stakeholders in education when the contents and framing of the science curriculum are opened for negotiations and change. A key concern for the reworking of the science curriculum is to re-establish relevance, meaning and significance of science learning based on changes in science and technology and their role in society. And also the changing values, concerns, interests, priorities, hopes and aspirations of an individual.

Although there might be some contextual factors that impact on effective learning, I do believe it is desirable to consider views of pupils on science content in designing curriculum. I do not argue that science curriculum should be determined solely from the viewpoint of what pupils find interesting. A balance between their views and specific ideas expected by subject matter specialists will be a good compromise. Teaching interesting content topics does not necessarily mean that good learning will be achieved, however, it makes sense that pupils will be greatly motivated to learn what interests them better than what they perceive to be boring.

14.3 Summary and conclusions

In reporting my findings of this research, I have tried to interpret and discuss the results by drawing on literature from affective studies in the area of science education research and a theoretical framework of social constructivism. This means that there are other disciplines, for instance, in sociology, psychology and youth research which could have been sought to inform such discussions on the way pupils responded to the ROSE questionnaire. But venturing into different disciplines needs to be done with caution when one's knowledge base is limited. This has been my major reason for keeping within science education research arena. Even in science education, there are a number of variables that could be used to give explanations and directions of responses given by the pupils. Some of these variables that could be considered are gender, age, teacher and peer factors, geographical background, individual experiences and socio-economic status of parents (Schreiner, 2006).

In this study, I have also interpreted, discussed and reported the results through the lenses of gender and geographical background differences, as well as against a background of pupils from diverse cultures. This study may be seen as an inventory of pupils' interests in, and views they hold for school science. However, I am of the view that the empirical evidence emerging from the study can inform science education community in Ghana and perhaps elsewhere in the science education research arena. The significance of the results will be evident in the on-going debate on some topical issues in science education studies, such as the search for the expected constitutive voice in science curricular content, curricular content vis-à-vis diverse culture; and other socio-scientific issues, such as science and technology careers, environmental challenges, gender, socio-economic status of parents and experiences outside school time activities in relation to science education. Many of such issues have been studied based on the ROSE instrument and empirical data, interpretations and discussions have been published elsewhere (see for example, Anderson *et al*., 2006; Schreiner, 2006; Lavonen *et al*., 2005; Schreiner and Sjøberg, 2004; Jones *et al*., 2001). Most of these studies have informed my discussions in this study.

The main purpose of this study was to elicit, describe and analyse the Ghanaian JSS pupils' experiences, interests, priorities, expectations and images that are of relevance to learning of science. The research explored a range of affective factors that might have a bearing on science education. This was made possible through the invitation of a sample of 1027 JSS3 pupils in the Central Region of Ghana to complete a ROSE survey designed questionnaire. I elicited pupils' science topics of interest, views about environmental challenges, relationships with school science, opinions about science and technology, priorities of future jobs and out-of-school science experiences.

This section presents an overview of the research undertaken and discussion of the findings obtained through the study.

14.3.1 Overview of the research

More specifically, this study investigated the affective domains (interests, attitudes, views, priorities and experiences) of JSS3 pupils with regard to school science learning. A critical component of this research was to discuss the findings against gender and geographical backgrounds; and further to compare with those of pupils of different cultures. Six specific socio-scientific issues in science education guided the framing of the six research questions. I also investigated the sample characteristics and traced the socio-economic status of the parents of the pupils and examined the impact on the quality of science education.

I started with an issue of science topics that interest pupils to learn about them. This and was addressed by the research question: What do children in Ghana want to learn about in science?

The second of the issues examined was about environmental protection and the research question was: What views do these children hold about environmental challenges?

The third issue was the attitudes towards school science and was addressed through the research question: How do these children relate to school science?

The important role science and technology is expected to play in a society within the context of the global environment of interdependency was the fourth issue and the research question which addressed the issue was: how do these children look at various aspects of the role of science and technology in society?

The fifth issue was about the important characteristics for a potential future job. This was addressed by the research question: What are the priorities of these children towards potential future occupation or job?

The last issue was about out-of-school experiences that might have bearing on school science. This was addressed through the research question: What kinds of science-oriented experiences do these children have from their lives outside school? All these issues were discussed from gender and rural/urban pupils' perspectives and also through the lenses of the international patterns.

I formulated these research questions of this study using the international ROSE questionnaire. The ROSE questionnaire mostly consists of closed structured questions totalling 250 items and had six subsets, all on a 4-point Likert-type scale. This format offered the respondents fixed alternative responses. The subsets have headings: science topics to learn about; important for a future job; environmental challenge issues; necessity of school science; role of science and technology and out-of-school experiences. Items, number of books in the home, together with local items (parental education and occupation) were used to trace the socio-economic backgrounds of parents.

Research approach

The data collection approach for this study was a standard survey methodology within quantitative research tradition. The responses from the questionnaire were analysed through the use of SPSS, version 12.0.1 for Windows (SPSS Inc., 2003) and Excel. Descriptive statistics, *t*-test, and Cronbach's reliability test were conducted on the data. The descriptive statistics was provided to document the general attitudes, experiences, interests, priorities, expectations of JSS pupils towards science education. An independent sample 2-tailed *t*-test was used to explore the statistically significant differences in the items' mean. The conventional $p \leq 0.05$ level of probability was used as the basis for reporting whether significant differences existed between the groups of pupils' responses by gender, geographic location (urban and rural). An interview approach was used to validate pupils' responses to the questionnaire.

A total of 1027 pupils in JSS 3 from 24 schools in the year 2003 were involved. The 24 schools were selected from all the twelve districts in the Central Region of Ghana. The schools were representative of urban and rural settlements. Two schools, one each from urban and rural areas were selected from every district.

14.3.2 Discussion of the findings

The findings of the study were organized as responses to the research questions outlined in section 1.3.3. But I first looked at the outcome of the investigation of the sample characteristics and socio-economic status of parent backgrounds.

Sample characteristics and socio-economic status

The age range of the JSS3 pupils in this study was 10 to 23 years. The presence of the over-age and under-age was also found in a study conducted with Ghanaian JSS3 pupils by Towse and his colleague. They revealed an age span of 11 to 27 years (Towse, *et al*., 2005). The findings from the two studies suggest that the ages below and above national school average age of 15 years for this level is common in Ghana and perhaps other developing countries in Africa. The reason has been that some of the dropouts later re-join the mainstream, hence the presence of the over-age. The girls are more affected as a result of early pregnancy because of parental irresponsibility, poverty and the dropouts' biological desire and ignorance of the reproductive system. There was therefore, a clear disparity in the enrolment numbers of boys and girls, as well as rural and urban. A similar finding was indicated in a study, where the dropout rate was found to be greater on the average for girls than boys (Anamuah-Mensah, 1995).

The socio-economic status of parents in the study area was found to be low as evidence in their educational and occupational backgrounds (see figures 6-3 and 6-4). Most of the mothers had lower education and fathers equally had low education, however, there were a considerable number of the fathers and mothers in petty trading and subsistence farming. Therefore, I believe that children from such backgrounds are likely to be denied of pursuing quality science education and science related occupations, simply because parents cannot afford the logistics to support their children.

Poverty is found to be the most obvious factor militating against girls' and rural school pupils' participation in education in general. Many rural schools in the sample area are in poverty-stricken and marginalized environments, where parents because of their socio-economic status may find it difficult to support their children at school and are likely to forgo educating the girl-child for boy-child.

Research Question 1: What do children in Ghana want to learn about in science?

To answer the above question I used the data from a subset of the questionnaire with the theme 'what I want to learn about'. The theme consists of a group of 108 items (ACE items). It includes a number of science topics with some in similar scientific content put in different context. This theme was used to explore the kinds of science Ghanaian JSS3 pupils would want to learn. The idea about these items was to get empirical evidence to base the argument that children also have their own interests or needs, which are to be satisfied as they engage in school science. When these perceived interests are met in the design of a science curriculum, then they are likely to lead to a meaningful and relevant school science.

The limitations of these items are that they only focus on the issue of the science content, but they do not address the teaching method. There are different teaching methods and learning activities, which serve various learning purposes and have different capacities of exciting pupils and attracting interests (Schreiner and Sjøberg, 2004). It also becomes impossible to interpret, in this study, whether a teacher will be successful or not in teaching *interesting* topics using a particular teaching method. Another limitation is that apart from the 108 items, there may well be other topics not included in this number that pupils would have shown interest to learn about.

The results of this study on the science topics of interest indicated that there was a general interest in almost all the 108 items when mean values were considered.

This confirms earlier research studies related to pupils' topics of interest in science across different countries. These studies revealed that in the developing countries both genders have similar interesting and uninteresting topics though, to some varying degree. They also recorded higher mean values than the corresponding numbers for developed countries (Sjøberg, 2000b; Sjøberg and Schreiner, 2005a). The observation here showed eagerness on the part of the pupils to learn science either as a result of curiosity or inaccessible to education due to lack of logistics and financial resources. At the least opportunity available pupils would be enthused over learning. The lack of logistical and financial support is more likely to be the reason behind what I termed as in*accessible to education.* This is because the finding about socio-economic status of the sample area in this study indicated very low socio-economic status of parents.

Some of the strong areas of interest relating to science topics for which both genders were in favour included topics related to the self in areas of health and well being. For example, they saw it important to learn about diseases, such as HIV/AIDS, adequate nutrition, food security, sources of good drinking water and good health. These topics are of personal and societal relevance, which are some of the challenges facing Ghana. These perceived important science topics were well reflected in the responses of the learners in statements like: 'What can be done to ensure clean air and safe drinking water', 'What to eat to keep healthy and fit', 'How to exercise to keep the body fit and strong'. We may therefore acknowledge that a strong interest in a given topic may be the same for both genders. It is also noteworthy to see that both genders showed high levels of interest in learning about HIV/AIDS and how to control it and 'what to eat to keep healthy and fit'. It appeared that these topics have high relevance to the life styles of the learners and attracted the attention of both boys and girls. Pupils of both genders were also strongly attracted by topics that can be described as modern technology, for example, 'How computers work' and 'How mobile phones can send and receive message'. The majority of pupils who responded to the questionnaire did not have access to these types of technology, neither at school nor at home. The lack of access to computers at home and school was also revealed during the interviews. The strong interest in such topics may have some elements of fascination.

It is also interesting to note that most pupils did not consider some topics appropriate to learn in school science. Perhaps, those topics were of no practical, personal and societal relevance and non-scientific phenomena or unfamiliar processes in science. Some of these topics are myths about ghosts and witches (non-scientific and irrelevant), black holes, supernovas and other spectacular objects in outer space (unfamiliar phenomena).

The significant gender difference in some science topics among the pupils studied also emerged. On the list of interesting topics, for example, boys showed significantly higher enthusiasm for learning about 'How things like radios and television work', 'Optical instruments and how they work', 'The use of satellite for communication and other purposes', 'How to use and repair everyday electrical and mechanical equipment', 'How petrol and diesel engines work' and 'Rockets, satellites and space travel'. Almost all these topics are physical science (in particular physics) in nature and some practical aspects that include many of the fundamental areas of applied physics and engineering.

In contrast, girls continued to report more interest than boys in science that included aesthetics and biology. Girls were significantly more interested in learning more about 'Properties of gems and crystals and how these are used for beauty', 'Symmetries and pattern in leaves and flowers', 'How radioactivity affects the human body' and 'The ability of lotions and creams to keep the skin young' 'Phenomena that scientists still cannot explain'. It is easy to note that these topics geared towards beauty, aesthetics, self and wonder. Some of them are related to biology.

The findings above are in accordance with findings from earlier studies in many cultures (i.e. Clark, 1972; Mc Guffin, 1973; Gardner, 1985 and 1998). These evidences are in line with the results from the SAS-study (Sjøberg, 2000b).

Although there were exceptions to the perceived claim that boys are more interested in physical sciences and girls are more interested in the biological sciences, pupils' interests fitted these gender stereo-typical patterns. Boys had more interests to learn about some practical aspects of physical science whiles girls wanted to learn more about aesthetics and biology. The differences in this JSS boys' and girls' interests in some aspects of science suggest that science content-related interests may begin early (see Jones et al., 2001). However, an interesting aspect in this study regarding the findings is that most of the topics were rather gender neutral. As stated earlier, only seventeen (17) out of the 108 topics had statistically different means for boys and girls. The small number of topics which showed statistically gender difference reflected well when the topics were clustered into science subject areas. The majority of both boys and girls were attracted to subjects such as technology education, physics, and biology as well. Contrary to the findings from several studies, which revealed that boys were relatively more interested in physical science and girls more interested in biological science topics, both genders shared the same interests in the science subjects. Another interesting aspect of the part of this study concerning pupils' most preferred science topics and subjects is that the search for a science curriculum that is fair to all shades of pupils become easier to construct since their interests were not so diverse.

When we turn to the interests of urban and rural school pupils in the list of 108 items of science topics, there were similarities in the topics that appealed to them and those, which did not. They also did coincide with most of the interests of that of the genders. Thus both urban and rural school pupils also indicated similar appealing and unappealing topics. It could be expected that the majority of the rural pupils would not appear excited about sciences since rural children appear more disadvantaged at learning. Rather pupils from rural areas seemed to have higher levels of interest to learn about very high proportion of the science topics more than the urban pupils. This result did not confirm the findings from other studies elsewhere, which indicated that pupils' attitudes towards and aspirations in science were affected by their access to resources and could even lead pupils to dislike science the more (Webster and Fisher 2000; Barton 2001; Zuniga *et al.*, 2005). This is clear evidence that many young people did not appear to lose their interest for science and technology in schools as it has been reported for the majority of youth mainly in the highly developed societies (Atkin, 1996; Schreiner and Sjøberg, 2004). But rather, the evidence did support some studies elsewhere, which indicated a general interest for Ghanaian pupils' in school science (see Sjøberg, 2000a; 2000b; 2002a).

There were statistically significant differences in some of the selected science topics of interest for urban and rural school pupils. Though, their interest profiles did not follow a clear pattern. Some of the possible reasons behind their interests had already been indicated in 7.5.3 and 7.5.4. The pupils in rural areas showed higher levels of interest than urban school pupils in topics I perceive to be of some relevance to their daily life activity, such as farming, which is the main occupation of rural areas of Ghana. One of the science topics which attracted the attention of most of the rural school pupils was about 'Organic and ecological farming without use of pesticides and artificial fertilizer' which appeared to support their interest shown in 'How plants grow and reproduce'. The expression of higher level of interest for these topics by this group of pupils became obvious regarding the environment and the use of pesticide and artificial fertilizer. This may have strongly influenced the way they responded to the topic about the use of pesticide and artificial fertilizer. The response by pupils in the rural areas to this topic reinforced the impression that pupils in developing countries did indicate some remarkable high interest in topics that relate to the environment that was also found in the SAS-study (Sjøberg, 2000b).

There were some other topics that appeared to have personal and social relevance for the rural community. A list of science topics such as: 'Epidemics and diseases causing large losses of life', 'Medicinal use of plants', 'The possible radiation dangers of mobile phones and computers' and 'How different sorts of food are produced, conserved and stored'. The combating and control of diseases, food production, health and sanitation are some of the challenges that confront Ghana, as a developing country in Africa. These challenges are more likely to affect the communities that continue to be marginalized. Therefore, the rural pupils' interests in these aspects of science are in line with some of these challenges. Strikingly, as rural school pupils had interest in 'How mobile phones can send and receive messages' which tops the ten most popular science topics of the rural school pupils' list , they also tended to be interested in knowing about the negative effect of the use of mobile phones on human health. Although they showed interest in modern technology, they were particular about some of the negative effects of technology and appeared to indicate a higher level of interest than urban school pupils to learn about the possible radiation dangers of mobile phones and computers. These findings shed light on the relative importance of the geographical background aspect when it comes to the discussion of the science curriculum.

The majority of the urban pupils were more attracted to topics, which appeared to me as among the challenges that face urban societies in Ghana. These are related to health and environmental issues. Accordingly, the topics on 'Sexually transmitted diseases and how to protect against them', 'How alcohol and tobacco might affect the body' and 'How technology helps us to handle waste, garbage and sewage' were popular with the urban pupils. The urban pupils' higher levels of interest in these topics might have resulted in a possible awareness that continues to be created in most urban pupils through the facilities in urban areas, such as television programmes and to a less extent, the print media. Discussions on sexually transmitted diseases, alcohol and tobacco related diseases and management and effect of wastes, garbage and sewage are often done on electronic media. When such television discussions are encouraged could expose the majority of the urban population to responsible environmental practices. This could be expected since urban pupils had even shown higher levels of interest in these topics when given the opportunity to learn about them at school science.

It is noteworthy to recognize the pattern in the differences in the interest profiles between the groups of pupils (between genders and between urban/rural pupils).This emerged throughout the discussion of pupils' interest profiles relating some science topics. It is an indication that equity concerns in science curriculum should focus more on the gender differences and less on other aspects, such as geographical background or social class. This conclusion is based only on responses to science content aside factors that influence science learning.

Research Question 2: What views do these children hold about environmental challenges?

The answer to this question was made possible in this study through the analysis of responses by pupils to the list of 18 statements on some environmental issues that has the theme ''Me and the environmental challenges'' (D-items) in the questionnaire. The items were designed to assess pupils' attitudes and their sense of responsibility for environmental issues. The analysis indicated that both boys and girls wanted to practice responsible environmental behaviour, and appeared to associate themselves with the statement that people need to care more about protection of the environment. Schreiner and Sjøberg (2003) also confirmed the Norwegian pupils' general concern about the environment but showed low interest to learn about environmental protection at school. Unlike the Norwegian study, Ghanaian pupils were interested to learn environmental education as a school science subject.

There was awareness among both genders that their society is faced with environmental challenges and that the environmental problems were not being exaggerated. Through such awareness they appeared motivated to be part in the attempt to solve environmental problems, because pupils in this sample seemed to have belief in their abilities as individuals to make a significant contribution to environmental protection. The result of the analysis also revealed that Ghanaian pupils perceived human beings to be much more important than animals and believed that animals should not have the same right to life as people and that animal could be used in medical experiments to save human lives. This finding appeared to confirm pupils' general concerns for human health. In their study, Bonnet and Williams (1998) showed that pupils identified extinction of species as one of the many problems confronting the earth, however, it appeared Ghanaian pupils in this sample did not hold such a belief for the environment. It is possible to interpret this finding in many ways; pupils in the sample were probably placing matters of health high on the issues of challenges of life or it might be that the Ghanaian culture does not recognize animals to have some kinds of right.

However, their interests expressed in learning environmental education as component of school science might provide an avenue for pupils to acquire better knowledge about many aspects of environmental protection issues. Therefore, it is my belief that teaching needs to be based on pupils' attitudes towards, knowledge and conceptions of the environmental protection issues. The teacher focusing on these factors when teaching environmental education becomes easier as the overall picture that emerged from the analysis was that similar concerns were expressed for both appealing and unappealing environmental issues to genders and urban/rural pupils.

Research Question 3: How do these children relate to school science?

The above research question touched on the pupils' perception of their science classes, together with what they get out of science at school, and the necessity of science education. To obtain such views of pupils about school science, the questionnaire items on ''My science classes'' (F-items) was used. The result revealed a general high enthusiasm of both genders for school science, but boys were more zealous about it. The data also showed that both urban and rural pupils had very strong positive attitudes towards science, with an exception to the statement: 'school science is a difficult subject'.

They demonstrated their enthusiasm for their science classes when they agreed strongly to statements such as: 'school science is interesting; everybody should learn science at school and would like to get a job in technology'. This enthusiasm was also demonstrated in an earlier finding from the same data in this study in which pupils expressed willingness to learn or were interested in learning about almost all the science topics listed in sections ACE of the questionnaire. An interpretation that could be assigned to such response might be that school science continues to attract pupils' interest and curiosity. This was also shown during the interview when some of the interviewees indicated their interests in some aspects of science was based on the reason that they wanted to know more about them thus indicating *curiosity*.

Similarly it appeared from the result that both boys and girls perceived science to be fascinating, important and probably relevant. This is because the majority of the boys and girls responded to support the statements: 'the things that I learn in science at school will be helpful in my everyday life; school science has increased my curiosity about things we cannot yet explain; school science has taught me how to take better care of my health; and school science has shown me the importance of science for our way of living'.

However, compared with other school subjects, most boys in particular, preferred school science and girls on the other hand, saw school science as a difficult subject despite the claimed relevance of science. During the interview, a boy in rural school, for example, elaborated on the importance of science to himself and his everyday life but, asserted to the fact that some of his colleagues find science very difficult. The result confirms earlier studies in science education indicating that boys have greater interest in science than girls (see Dawson, 2000; Osborne and Collins, 2001; Colley *et al*., 2003). It is also in line with that of Jones' *et al*. (2000) study, which revealed that more females than males perceived science as difficult to understand and as involving experiments. As mentioned, the perception of girls that science is somehow difficult was probably demonstrated in the TIMSS 2003 study. In Ghana, there was large gender difference in science achievements. In that study, the boys performed better than the girls in all the content areas in science (Anamuah-Mensah *et al.*, 2004). Other studies also indicated that, though, pupils were excited and inspired as they relate to science, they also perceived science to be mathematical and difficult (see Anamuah-Mensah, 1995; Sjøberg, 2002c). Despite their difficulty in school science, they did not reject school science. In the majority of the responses, the emphasis was on the general value of science in daily living and in society, with most of their choices illustrating examples of the instrumental value (practical and usable) of school science.

The overall picture also showed that irrespective of geographical location/background of pupils, both urban and rural school pupils were excited about their science classes. However, urban pupils were much more positive than the rural group. This result has been the general pattern in many developing countries with regard to young learners' relationships with school science. I have cited extensively in this study from many research studies in affective domain, the reasons behind such interests in school science despite the difficult levels expressed by some of pupils in the sample area.

Although the two groups' attitudes towards their school science regarding levels of agreement differ, all the groups were strongly in agreement with the statements that the science they learn at school will improve their career chances. Perhaps, through learning, school science has opened their eyes to new and exciting jobs; and would like to get job in technology or would like to become scientists. However, the rural school pupils' interests in becoming scientists seemed to be more than that of urban pupils. This might be expected since rural pupils also showed very high levels of interest in learning almost all the science-related topics that were listed in the subsets ACE of the ROSE questionnaire.

Hence, the findings give a support to a statement by Sjøberg (2002b) that personal and societal interests are key factors for engaging in science education. It also accords the fact that altitudes are far more important than cognitive factors on the account of subject choice. It has been noted in some studies that the affective factors of learning are important determinants for the choice of school subjects (Gardner, 1975; Schreiner and Sjøberg, 2004). I am also of the view that the findings in general from this study provide hope to science education community that irrespective of gender and geographical background differences, pupils hold positive attitudes towards school science. Therefore, science education programmes that are planned relevant to pupils are likely to attract their attention.

Research Question 4: How do these children look at various aspects of the role of science and technology in society?

The essence of the above research question was to obtain information on the opinions of Ghanaian pupils in this study towards the role and function of science and technology in society. In my view as a science educator, when such opinions are sought and are positive, they can motivate pupils to engage in science and technology education. A section of the ROSE questionnaire labelled G has a title 'My opinion about science and technology' is made up of 16 items that present some various aspects of the role of science and technology in society was used to elicit such opinions of pupils.

The analysis of their responses indicated that the majority of boys and girls appeared to have opinions that has more to do with the belief in and widespread respect for science and technology (a number of mean score values > 3.0). The interests in science and technology among girls were on about the same level as boys and differences were not pronounced.

Both boys and girls appeared to appreciate the possibility of science and technology and believed more in the benefits of science and technology, such as goods and welfare, than the harmful effects. This was made evident in both genders' strong agreements with similar statements: 'science and technology are important for society; science and technology make our lives healthier, easier and more comfortable; a country needs science and technology to become developed; new technologies will make work more interesting; thanks to science and technology, there will be greater opportunities for future generations; science and technology will find cures to diseases such as HIV/AIDS and cancer; the benefits of science are greater than the harmful effects it could have; and that scientists follow the scientific method that always leads them to correct answers'. Pupils' beliefs in science and technology appeared to be the source of their very high interest in learning about modern technology and also the interests expressed in technology education.

In which way one interprets these findings, in a less developed country, like Ghana, such empirical evidence that emerged from their responses becomes obvious. A study elsewhere indicated that the level of technological development in a country is a key factor for explaining the expectations people have of further developments of science and technology (Schreiner, 2006). In a country, which is still faced with the challenges of underdevelopment, young learners would expect the application of science and technology to play a key role. The role includes providing goods and welfare services to meet those challenges to healthier lives, more comfortable living, opportunity to find cures to diseases and solving environmental problems in their society. Their views on science and technology appeared to be in line with the suggestion put forward by Lewin (1993) that school science (and technology) education must be geared towards the solving basic social and environmental needs of the people. However, such positive views may influence the general perceptions of pupils about science and technology and are not likely to realize the limitations and possible harmful effects. It appears these limitations and harmful effects were not of any immediate concerns to pupils as they were in strong agreement that the benefits of science are greater than harmful effects it could have. Perhaps they did not have any knowledge about the magnitude of such harmful effects on humans or they were only after finding solutions to their social and environmental needs.

Both urban and rural school pupils also held positive views and respect for science and technology. The rural pupils in particular, expressed a stronger belief that science and technology are helping the poor. It appeared the majority of the rural pupils were basing their response to this statement on the socio-economic conditions in which they find themselves in their communities. They probably had the beliefs that the application of science and technology could transform their present socio-economic conditions to better conditions of life.

It is important that school science education reflects these findings if it is to adequately prepare school leavers for a meaningful future world life to fully participate in social and economic development. More importantly, the current focus of interest on technological matters is of central interest to all groups of pupils. Some change in content and the style of teaching to an extent, I believe, will lead to a significant increase in the choice of physical science by girls in particular.

This suggests that the values, beliefs, concerns and expectations pupils hold for science and technology might influence their motivation to engage in science and technology studies. Teaching needs therefore to be based on pupils' knowledge, views and conceptions of science and technology issues.

Research Question 5: What are the priorities of these children towards potential future occupation or job?

It has been revealed in some studies that different hopes and priorities pupils hold for their future could be a factor in the choice of a future occupation or job and might even influence their eagerness to learn (Shmurak, 1998; Lewis and Collins, 2001). Such job qualities regarded as relevant for future occupation, becoming part of the science curriculum emphasis and the knowledge that teachers have in these qualities might be an important factor for learning.

Therefore, another way of making science education relevant to young learners may be to pursue what pupils hold as their priorities towards a potential future occupation or job. This was made possible when the fifth research question was answered through the use of one of the subsets of the questionnaire labelled B and has a theme 'My future job'. This subset has a list of 26 items that present job qualities which are likely to be some of the hopes, aspirations and priorities pupils might perceive to be important for their future job.

The answers to the 26 items on ‘My future job’ revealed a set of job priorities that appeared similar for both boys and girls, as well as between urban and rural school pupils. For both genders, the most interesting aspect of pupils’ job priorities(both appealing and unappealing) is that the girls in this study shared with boys in most of the boys’ job priorities, which has been described and discussed in more detail in section 11.3.1. However, relative to each other, most girls preferred jobs in which there will be possibility of making their own decisions and controlling other people. Boys, on the other hand, seemed to be more attracted than girls to work with something easy and simple, to work with machine or tools and job which abilities and knowledge are developed and improved.

By and large women are noted to be poorly represented in the decision- making positions and top positions at workplaces, which are mostly occupied by men. The girls’ interests in jobs that will provide them with opportunities to make their own decisions and control people are in positive direction towards the emancipation of women, thereby not limiting them by traditional ideas about what women can do. Perhaps, because of this reason and *much talk about* gender equity, the present generation of girls in this study would want to break away from the vocational expectations and goals of girls which are mostly confined to the ‘traditional female occupations’ (Jones *et al*., 2000), such as hair dressing, dress making and sales representative (Schwedes, 2005). They would also want to disentangle themselves from the perceived submissiveness that is believed to be exercised by women at workplace (Twshene, 2003). There could be several factors that might have influenced the girls’ goals towards job priority, such as the outcomes of the STME clinics, increasing presence of role models, encouragement and support from girl-child education unit in Ghana. But at this level of their education, the pupils, in particular, girls may not have an adequate knowledge about science and technology related job areas were they can meet their goals. As science educators we could make use of an empirical finding of this nature and provide information and knowledge about such goals about science related careers as pupils engage in science education.

The majority of the boys, as stated above, were more in favour than girls of jobs that will develop or improve their knowledge and abilities, make work easy and simple; and work that will involve the use of machines or tools. The higher interest of boys than girls in the use of machines or tools and the use and repair of everyday electrical and mechanical equipment might affect girls negatively when it comes to the use of science equipment during the science practical lesson, especially in physics practical lesson. It is likely that girls will not develop interests or be motivated enough to venture into science related professions that have the above characteristics, for example, in the areas of electrical and mechanical engineering. However, girls could be reminded and encouraged to recognize other professions in the physical science where they can excel to meet their goals of making their own decisions and perhaps have the opportunity not only to become *boss* or control people but also to help people and the society. The jobs in technology might be one of such areas where girls given the opportunity are likely to excel, since they showed interests in technology in general and modern technology in particular, such as in computers.

Both the urban and the rural groups prioritized almost similar job qualities, where knowledge and abilities are either developed or improved, one can become the boss at the workplace, help people, and come up with new ideas and use talents and abilities. In addition, all groups would want to work with something they find important and meaningful and also work with people rather than things. But these qualities come out in a rather mixed order. The differences in the job priorities also did not appear in clear pattern with regard to geographical background differences. However, the urban pupils showed a lot more interest to work in the area of environmental protection. This could be an area of work where there could be the possibilities to help and work with other people as they indicated elsewhere in this study that they agreed strongly to the involvement of everybody in the environmental protection.

A potential future job in which one could earn lots of money attracted the attention of all pupils but in particular, the rural pupils. Furthermore, more of the rural pupils than urban pupils were interested in becoming famous and to work independently of other people. It appears earning lots of money has become motivational factor generally for the present generation of the youth towards employment (see Lavonen *et al.*, 2005; Clewell and Campbell 2002). There are other interesting fields of work with respect to making lots of money that could attract the attention of pupils. However, fewer people succeed in those areas, such as fields of sports and entertainments. It is also a fact that not everyone can succeed in making lots of money in many of science and technology jobs, especially in terms of higher salaries compared to some professions mentioned above. However, pupils could be made aware of the types of professions in the science and technology areas, for example, scientists, engineers, technicians and technologist, which Ghana needs most urgently to overcome its challenges of underdevelopment. Through these professions, they could meet their goals of helping their communities, other pupils and the nation.

I believe that when these values the groups of pupils hold for future job are associated with professions in science and technology fields, individuals may be attracted to taking science and technology at school.

Research Question 6: What kinds of science-oriented experiences do these children have from their lives outside schools?

The import of this and the last research questions in this study was to explore the possible out-of-school experiences that may exist among school pupils, which may have a bearing on the teaching and learning of school science. Citing such experiences fairly in the science classes could increase the understanding of new concepts and skills when they are introduced.

To elicit such experiences, a section of the questionnaire labelled H, with the theme ‘My out-of-school experiences’ was engaged. This section has an inventory of some 61 activities sought to explore the kinds of experiences pupils have outside school time.

As it has run through all the findings so far, the gender differences as well as the urban/rural differences in most of the aspects of the issue concerning science education (such as pupils' interests, images, opinions, expectations, priorities and experiences that are of relevance for learning of science) had not been pronounced. The gender differences in outside school time experiences, as expected, did not also appear pronounced. This is a positive indication for the designers of science curriculum and the writers of science textbooks that could be fair to both genders.

The results from their responses on the items showed that both genders and urban/rural pupils had involved more in similar activities, such as, cooking a meal, making a fire from charcoal or wood, preparing food over open fire or stove burner, experiencing illness and getting medical treatment; and also experiencing nature or science through books, magazine, films, and TV programmes. In addition, all pupils had experiences in using measuring ruler, tape or stick to measure and planting seeds and watching them grow. A number of these activities could be linked with some curriculum contents in physical and biological sciences.

However, among the girls, the majority of them dominated in activities such as collecting edible berries, fruits, mushrooms or plants; knitting and weaving, and baking bread, pastry and cake. They also had experience in being in a hospital as a patient. These are closer to biological science topics. On the contrary, most of the boys had more experience in using of tools like a saw, screwdriver or hammer and also in an activity that involves the opening of a device, such as radio, watch, computer and telephone to find out how it works. Such topics link more to topics in physics. The gender differences in extracurricular activities are similar to those reported in other studies elsewhere (see Lavonen *et al.*, 2005; Jones *et al.*, 2000). The boys' and girls' out-of-school activities in this study give credence to some studies on pupils' outside school time activities, which indicated that most often boys' extracurricular activities had more bearing on physical science, while that of girls had more to do with biological sciences

(Sjøberg, 2002a; 2000b; Baker and Leary, 1995; Kahle and Lake 1983). Girls are likely to face more challenges in an attempt to learn physical science topics since their experiences seem to have no great weight in school science.

For urban and rural pupils, the activities, such as 'using a compass to find direction; opening a device (radio, watch, computer and telephone) to find out how it works and reading a map to find my way' were more popular with the urban pupils whiles experiences in collecting edible berries, fruits, mushrooms or plants; planting seeds and watching them grow; and walking while balancing an object on the head were in favour of the rural school pupils. The urban pupils' activities reflected more on topics in the physical science and are likely to have better understanding of concepts which may have linkages with these activities than the rural pupils. This is because the rural pupils' out-of-school experiences were more of biological orientated topics.

Most of the activities all groups of pupils claimed they frequently involved themselves in have some bearing on the science topics they would want to learn about, which have been described and discussed in chapter 7. Therefore, it becomes valuable for a teacher to gain an insight into kinds of extracurricular experiences which are likely to exist among young learners that learning new concepts and skills in science can be linked to enhance understanding. But girls and rural pupils in particular, when given same opportunity to learn science as boys and urban pupils, they could do better since they had expressed interests to learn some similar science topics with that of the boys and urban pupils. Furthermore, when girls show interests in boys' extracurricular activities they must be encouraged to do so, in order to expand the base of girls' out-of-school activities and have equal weight in activities that are of relevance for science learning.

International comparison

According to Sjøberg and Schreiner (2005b), the position of science and technology in a society changes through time from one society to another. This is confirmed in this study when comparisons were made across countries on how learners relate to science and technology. It was revealed that many young learners in the developing countries would want a career in science and technology. For example, they would like to become scientists and also opt for a job in technology, while in many developed countries pupils declined to take jobs in these areas. In all countries, the youth would want a job that is characterized by developing knowledge, abilities and helping other people. All groups of pupils in each country recognized the role of science and technology in society.

The study showed that on the average, the majority of young learners across countries were somewhat interested in school science. However, in the developed countries, pupils' interests were lower than their counterparts in the less developed countries. Young learners in the developed countries were of more interest in other school subjects than school science as compared to the views expressed by pupils in the less developed countries. Gender differences varied also from one country to another on the issues concerning science and technology. In most countries the differences in interests were larger in the developed countries and in favour of boys.

Across all cultures, pupils had positive attitudes towards the environmental challenges and were optimistic about the future world. But despite the general respect for the role of science and technology in society, the majority of pupils in the medium and high HDI countries did not believe that science and technology can solve all environmental problems.

14.4 Recommendations

The recommendations are organized in two parts: for the curriculum policy makers, textbook authors, and science teachers; and for further research.

14.4.1 The curriculum policy makers, textbook authors, and science teachers

Curriculum policy makers

It appears the traditional curriculum reinforces the masculine characterization of science as abstract and disconnected from social and environmental concerns. It also associates science education with pedagogy of telling or transmitting knowledge. The findings of this study and the insight they offer for school science curriculum demand a shift. It is recommended that the traditional science curriculum is replaced by a curriculum that emphasized on replacing the transmission of knowledge approach by approach of relevance. This approach should stress curriculum's scientific content that is directly applicable to everyday science-related problem solving. This demands a reconstruction of the content-driven curriculum to shift more to a context-driven science.

Policy makers should make spirited effort to produce a relevant science curriculum. In the development of curricular materials and instructional protocols due recognition should be given not only to interests, opinions, images, priorities, expectations, experiences and prior knowledge they hold for science, but also to gender as well as geographical differences. The implication is that the curriculum must be established by determining balanced views of all educational stakeholders, including that of the pupils whom the school science is meant for. Such a situation would open more opportunities for pupils to meaningful and relevant science education. Furthermore, the results of this investigation might be disseminated effectively to parents, educators and others who influence these learners' decisions.

Textbook authors

This study suggests that background experiences may play an important role in enhancing understanding of new concepts. Therefore, publishers and authors of school textbooks must be made aware of the research findings, so that pupils' interests can be included in the school textbooks through feedback from research.

This is because since 2005, the government of Ghana has contracted publishers who have produced textbooks for Basic Schools using Ghanaian authors to address this concern. These are the textbooks which are currently being used in the schools. In fact they were supplied free of charge to all pupils in the Basic Schools.

Science teachers

It is recommended that school provide adequate direction and support to its science learners. Pupils need the type of science education that can assist them to solve daily life problems. Teachers are expected to play a key role in achieving this. The findings from this study have clear implication for teachers. To avoid girls and marginalized groups of pupils remaining on the sidelines of science, teachers are to show the responsibility of presenting science as equally appropriate, including an engagement of thoughtful science activities for both genders and pupils of different geographical backgrounds.

I am concerned about the current trend within educational institutions to treat all pupils identically, particularly when planning for science instruction. The diversity of pupils in today’s classrooms contributes to an interesting complexity of individual needs, including affective experiences of learning. Good teachers become accountable to the pupils on these issues and adjust the curriculum accordingly.

For example, the findings from this study appear to suggest that pupils appreciate the valuable role the science they learn at school will play in their everyday lives and that of the community. To foster pupils’ interests in school science, it is essential for science teachers to make clear the wide range of opportunities which are available through the acquisition of scientific knowledge or qualification. Typically, all pupils in this sample would want a career that will earn them a lot of money; implicit assumption is that pupils’ knowledge of the range of science related occupations that are likely to earn them a lot of money is limited. Teachers should therefore, make effort to give specific examples and also emphasize the value of science qualifications in a wide range of occupations during teaching.

14.4.2 Recommendations for further research

Since the gender gap still exists in areas of science learning and also considering the transient nature of affective factors of learning overtime, I would recommend that further research with more than 24 schools and covering other regions is conducted as a follow up to this study. It should also include other factors influencing the learning of science, for example.

- parent influences;
- peer influences; and
- teacher-pupil interaction.

Over time, closed-ended questions have become increasingly popular compared with open-ended questions which are asked less frequently (Smith, 1987). Research has shown that there are distinct disadvantages to closed-ended questions. For example, respondents tend to confine their answers to the choices offered (Presser, 1990). The respondents are generally deprived of the opportunity to suggest a response and simply select among those listed, even if the best answer is not included. A closed-ended question can only be used effectively if its answer choices are comprehensive, and this is difficult to assure. The ROSE instrument was also limited in the types and number of universe of items that pupils had available for selection. It is arguable that different items other than the ones listed in the ROSE instrument could lead to different conclusions regarding pupils' science experiences. In the light of this; I suggest an interview approach to be incorporated in a study of this nature in future. Pupils' affective dispositions towards science and technology through interviews are likely to enhance data quality and a better interpretation of results.

Furthermore, much of the research that has sought to examine pupils' attitudes with regard to school science has been reliant on questionnaires. According to

Gardner (1975, cited in Osborne and Collins, 2001), this body of research has attracted a number of criticisms, mainly for attempting to reduce a complex, and mutually dependent construct to a few easily measurable quantitative dimensions. However, Osborne and Collins (2001) have noted that there are relatively few studies of pupils' attitudes to science, which have adopted a qualitative approach to elicit in some depth pupils' views and their rationale. According to them, in adopting solely a qualitative, interviewed-based approach seeking to explore pupils' views of their experience of school science will add fresh insights into its nature and quality.

I am of the opinion that the science curriculum cannot be in a form, which respects solely the current values and interests of learners; and also to base teaching of school science on opinions of pupils. Nevertheless, this study has added to the needed information on affective factors of importance to the learning of science and technology. This might guide the on-going debate among science education research community on the search for a *local* science curriculum that to some degree recognizes the voice of the learners who are the beneficiaries of the school science.

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APPENDICES

Appendix A.

The ROSE questionnaire including some local items.

The questionnaire that was administered to the pupils is as shown in the pages 320 to 332.

ROSE

The Relevance of Science Education

This booklet has questions about you, and about your experiences and interests related to science in school and outside school.

There are no correct or incorrect answers, only answers that are right for you. Please think carefully and give answers that reflect your own thinking.

This questionnaire is being given to pupils in many different countries. That is why some questions may seem strange to you. If there is a question you do not understand, just leave it blank. If you are in doubt, you may ask the teacher, since this is not a test!

For most questions, you simply put a tick in the appropriate box.

The purpose of this questionnaire is to find out what pupils in different parts of the world think about science at school as well as in their everyday life. This information may help us to make schools better.

Your answers are anonymous, so please; do not write your name on this questionnaire.

THANK YOU!
Your answers will be a big help.

START HERE:

I am a □ girl □ boy

I am ______ years old

I live in ____________________ (write the name of your country

Name of School____
Location of School: urban/rural____
District____
Place of birth____
Father's occupation____
Father's education: None □ Primary □ Middle School/JSS □
Senior Secondary/Technical □ College/University □
Mother's occupation____
Mother's education: None □ Primary □ Middle School/JSS □
Senior Secondary/Technical □ College/University □

A. What I want to learn about
How interested are you in learning about the following?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not intere sted	*Slightly not intere sted*	*Inte- res- ted*	*Very interes- ted*
1.	Stars, planets and the universe	☐	☐	☐	☐
2.	Chemicals, their properties and how they react	☐	☐	☐	☐
3.	The inside of the earth	☐	☐	☐	☐
4.	How mountains, rivers and oceans develop and change	☐	☐	☐	☐
5.	Clouds, rain and the weather	☐	☐	☐	☐
6.	The origin and evolution of life on earth	☐	☐	☐	☐
7.	How the human body is built and functions	☐	☐	☐	☐
8.	Heredity, and how genes influence how we develop	☐	☐	☐	☐
9.	Sex and reproduction	☐	☐	☐	☐
10.	Birth control and contraception	☐	☐	☐	☐
11.	How babies grow and mature	☐	☐	☐	☐
12.	Cloning of animals	☐	☐	☐	☐
13.	Animals in other parts of the world	☐	☐	☐	☐
14.	Dinosaurs, how they lived and why they died out	☐	☐	☐	☐
15.	How plants grow and reproduce	☐	☐	☐	☐
16.	How people, animals, plants and the environment depend on each other	☐	☐	☐	☐
17.	Atoms and molecules	☐	☐	☐	☐
18.	How radioactivity affects the human body	☐	☐	☐	☐
19.	Light around us that we cannot see (infrared, ultraviolet)	☐	☐	☐	☐
20.	How animals use colours to hide, attract or scare	☐	☐	☐	☐
21.	How different musical instruments produce different sounds	☐	☐	☐	☐
22.	Black holes, supernovas and other spectacular objects in outer space	☐	☐	☐	☐
23.	How meteors, comets or asteroids may cause disasters on earth	☐	☐	☐	☐

		Not interested	Slightly not interested	Interested	Very interested
24.	Earthquakes and volcanoes	☐	☐	☐	☐
25.	Tornados, hurricanes and cyclones	☐	☐	☐	☐
26.	Epidemics and diseases causing large losses of life	☐	☐	☐	☐
27.	Brutal, dangerous and threatening animals	☐	☐	☐	☐
28.	Poisonous plants in my area	☐	☐	☐	☐
29.	Deadly poisons and what they do to the human body	☐	☐	☐	☐
30.	How the atom bomb functions	☐	☐	☐	☐
31.	Explosive chemicals	☐	☐	☐	☐
32.	Biological and chemical weapons and what they do to the human body	☐	☐	☐	☐
33.	The effect of strong electric shocks and lightning on the human body	☐	☐	☐	☐
34.	How it feels to be weightless in space	☐	☐	☐	☐
35.	How to find my way and navigate by the stars	☐	☐	☐	☐
36.	How the eye can see light and colours	☐	☐	☐	☐
37.	What to eat to keep healthy and fit	☐	☐	☐	☐
38.	Eating disorders like anorexia or bulimia	☐	☐	☐	☐
39.	The ability of lotions and creams to keep the skin young	☐	☐	☐	☐
40.	How to exercise to keep the body fit and strong	☐	☐	☐	☐
41.	Plastic surgery and cosmetic surgery	☐	☐	☐	☐
42.	How radiation from solariums and the sun might affect the skin	☐	☐	☐	☐
43.	How the ear can hear different sounds	☐	☐	☐	☐
44.	Rockets, satellites and space travel	☐	☐	☐	☐
45.	The use of satellites for communication and other purposes	☐	☐	☐	☐
46.	How X-rays, ultrasound, etc. are used in medicine	☐	☐	☐	☐
47.	How petrol and diesel engines work	☐	☐	☐	☐
48.	How a nuclear power plant functions	☐	☐	☐	☐

B. My future job

How important are the following issues for your potential future occupation or job?

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

		Not Impor-tant	*Slightly not Impor-tant*	*Impor-tant*	*Very Impor-tant*
1.	Working with people rather than things	☐	☐	☐	☐
2.	Helping other people	☐	☐	☐	☐
3.	Working with animals	☐	☐	☐	☐
4.	Working in the area of environmental protection	☐	☐	☐	☐
5.	Working with something easy and simple	☐	☐	☐	☐
6.	Building or repairing objects using my hands	☐	☐	☐	☐
7.	Working with machines or tools	☐	☐	☐	☐
8.	Working artistically and creatively in art	☐	☐	☐	☐
9.	Using my talents and abilities	☐	☐	☐	☐
10.	Making, designing or inventing something	☐	☐	☐	☐
11.	Coming up with new ideas	☐	☐	☐	☐
12.	Having lots of time for my friends	☐	☐	☐	☐
13.	Making my own decisions	☐	☐	☐	☐
14.	Working independently of other people	☐	☐	☐	☐
15.	Working with something I find important and meaningful	☐	☐	☐	☐
16.	Working with something that fits my attitudes and values	☐	☐	☐	☐
17.	Having lots of time for my family	☐	☐	☐	☐
18.	Working with something that involves a lot of travelling	☐	☐	☐	☐
19.	Working at a place where something new and exciting happens frequently	☐	☐	☐	☐
20.	Earning lots of money	☐	☐	☐	☐
21.	Controlling other people	☐	☐	☐	☐
22.	Becoming famous	☐	☐	☐	☐
23.	Having lots of time for my interests, hobbies and activities	☐	☐	☐	☐
24.	Becoming 'the boss' at my job	☐	☐	☐	☐
25.	Developing or improving my knowledge and abilities	☐	☐	☐	☐
26.	Working as part of a team with many people around me	☐	☐	☐	☐

C. What I want to learn about
How interested are you in learning about the following?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	Not inters-ted	*Slightly not intere s-ted*	*Inter ested*	*Very interes ted*
1. How crude oil is converted to other materials, like plastics and textiles	☐	☐	☐	☐
2. Optical instruments and how they work (telescope, camera, microscope, etc.)	☐	☐	☐	☐
3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	☐	☐	☐	☐
4. How cassette tapes, CDs and DVDs store and play sound and music	☐	☐	☐	☐
5. How things like radios and televisions work	☐	☐	☐	☐
6. How mobile phones can send and receive messages	☐	☐	☐	☐
7. How computers work	☐	☐	☐	☐
8. The possibility of life outside earth	☐	☐	☐	☐
9. Astrology and horoscopes, and whether the planets can influence human beings	☐	☐	☐	☐
10. Unsolved mysteries in outer space	☐	☐	☐	☐
11. Life and death and the human soul	☐	☐	☐	☐
12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	☐	☐	☐	☐
13. Why we dream while we are sleeping, and what the dreams may mean	☐	☐	☐	☐
14. Ghosts and witches, and whether they may exist	☐	☐	☐	☐
15. Thought transference, mind-reading, sixth sense, intuition, etc.	☐	☐	☐	☐
16. Why the stars twinkle and the sky is blue	☐	☐	☐	☐
17. Why we can see the rainbow	☐	☐	☐	☐
18. Properties of gems and crystals and how these are used for beauty	☐	☐	☐	☐

D. Me and the environmental challenges
To what extent do you agree with the following statements about problems with the environment (pollution of air and water, overuse of resources, global changes of the climate etc.)? (Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	Dis-agree	*Slightly Dis-agree*	*Slightly Agree*	*Agree*
1. Threats to the environment are not my business	☐	☐	☐	☐
2. Environmental problems make the future of the world look bleak and hopeless	☐	☐	☐	☐
3. Environmental problems are exaggerated	☐	☐	☐	☐
4. Science and technology can solve all environmental problems ...	☐	☐	☐	☐
5. I am willing to have environmental problems solved even if this means sacrificing many goods..	☐	☐	☐	☐
6. I can personally influence what happens with the environment	☐	☐	☐	☐
7. We can still find solutions to our environmental problems	☐	☐	☐	☐
8. People worry too much about environmental problems	☐	☐	☐	☐
9. Environmental problems can be solved without big changes in our way of living...	☐	☐	☐	☐
10. People should care more about protection of the environment....	☐	☐	☐	☐
11. It is the responsibility of the rich countries to solve the environmental problems of the world	☐	☐	☐	☐
12. I think each of us can make a significant contribution to environmental protection...	☐	☐	☐	☐
13. Environmental problems should be left to the experts	☐	☐	☐	☐
14. I am optimistic about the future	☐	☐	☐	☐
15. Animals should have the same right to life as people	☐	☐	☐	☐
16. It is right to use animals in medical experiments if this can save human lives	☐	☐	☐	☐
17. Nearly all human activity is damaging for the environment...........	☐	☐	☐	☐
18. The natural world is sacred and should be left in peace...............	☐	☐	☐	☐

E. What I want to learn about
How interested are you in learning about the following?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	Not inters-ted	*Slightly not interes-ted*	*Inter ested*	*Very interest ed*
1. Symmetries and patterns in leaves and flowers	☐	☐	☐	☐
2. How the sunset colours the sky	☐	☐	☐	☐
3. The ozone layer and how it may be affected by humans	☐	☐	☐	☐
4. The greenhouse effect and how it may be changed by humans	☐	☐	☐	☐
5. What can be done to ensure clean air and safe drinking water .	☐	☐	☐	☐
6. How technology helps us to handle waste, garbage and sewage	☐	☐	☐	☐
7. How to control epidemics and diseases	☐	☐	☐	☐
8. Cancer, what we know and how we can treat it	☐	☐	☐	☐
9. Sexually transmitted diseases and how to be protected against them..	☐	☐	☐	☐
10. How to perform first-aid and use basic medical equipment	☐	☐	☐	☐
11. What we know about HIV/AIDS and how to control it	☐	☐	☐	☐
12. How alcohol and tobacco might affect the body	☐	☐	☐	☐
13. How different narcotics might affect the body	☐	☐	☐	☐
14. The possible radiation dangers of mobile phones and computers	☐	☐	☐	☐
15. How loud sound and noise may damage my hearing	☐	☐	☐	☐
16. How to protect endangered species of animals	☐	☐	☐	☐
17. How to improve the harvest in gardens and farms	☐	☐	☐	☐
18. Medicinal use of plants	☐	☐	☐	☐
19. Organic and ecological farming without use of pesticides and artificial fertilizers	☐	☐	☐	☐
20. How energy can be saved or used in a more effective way	☐	☐	☐	☐
21. New sources of energy from the sun, wind, tides, waves, etc. ...	☐	☐	☐	☐
22. How different sorts of food are produced, conserved and stored	☐	☐	☐	☐
23. How my body grows and matures	☐	☐	☐	☐

	Not inters-ted	*Slightly not interes-ted*	*Interested*	*Very interested*
24. Animals in my area	☐	☐	☐	☐
25. Plants in my area	☐	☐	☐	☐
26. Detergents, soaps and how they work	☐	☐	☐	☐
27. Electricity, how it is produced and used in the home	☐	☐	☐	☐
28. How to use and repair everyday electrical and mechanical equipment	☐	☐	☐	☐
29. The first landing on the moon and the history of space exploration	☐	☐	☐	☐
30. How electricity has affected the development of our society	☐	☐	☐	☐
31. Biological and human aspects of abortion	☐	☐	☐	☐
32. How gene technology can prevent diseases	☐	☐	☐	☐
33. Benefits and possible hazards of modern methods of farming	☐	☐	☐	☐
34. Why religion and science sometimes are in conflict	☐	☐	☐	☐
35. Risks and benefits of food additives	☐	☐	☐	☐
36. Why scientists sometimes disagree	☐	☐	☐	☐
37. Famous scientists and their lives	☐	☐	☐	☐
38. Big blunders and mistakes in research and inventions	☐	☐	☐	☐
39. How scientific ideas sometimes challenge religion, authority and tradition	☐	☐	☐	☐
40. Inventions and discoveries that have changed the world	☐	☐	☐	☐
41. Very recent inventions and discoveries in science and technology	☐	☐	☐	☐
42. Phenomena that scientists still cannot explain	☐	☐	☐	☐

F. 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.)

	Dis-agree □	*Slightly Dis-agree*□	*Slightly Agree*□	*Agree*
1. School science is a difficult subject	☐	☐	☐	☐
2. School science is interesting	☐	☐	☐	☐
3. School science is rather easy for me to learn	☐	☐	☐	☐
4. School science has opened my eyes to new and exciting jobs	☐	☐	☐	☐
5. I like school science better than most other subjects	☐	☐	☐	☐
6. I think everybody should learn science at school	☐	☐	☐	☐
7. The things that I learn in science at school will be helpful in my everyday life	☐	☐	☐	☐
8. I think that the science I learn at school will improve my career chances	☐	☐	☐	☐
9. School science has made me more critical and sceptical	☐	☐	☐	☐
10. School science has increased my curiosity about things we cannot yet explain	☐	☐	☐	☐
11. School science has increased my appreciation of nature.......	☐	☐	☐	☐
12. School science has shown me the importance of science for our way of living	☐	☐	☐	☐
13. School science has taught me how to take better care of my health	☐	☐	☐	☐
14. I would like to become a scientist	☐	☐	☐	☐
15. I would like to have as much science as possible at school	☐	☐	☐	☐
16. I would like to get a job in technology	☐	☐	☐	☐

G. My opinions about science and technology
To what extent do you agree with the following statements?
(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

	Dis-agree	*Slightly Dis-agree*	*Slightly Agree*	*Agree*
1. Science and technology are important for society	☐	☐	☐	☐
2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	☐	☐	☐	☐
3. Thanks to science and technology, there will be greater opportunities for future generations	☐	☐	☐	☐
4. Science and technology make our lives healthier, easier and more comfortable	☐	☐	☐	☐
5. New technologies will make work more interesting	☐	☐	☐	☐
6. The benefits of science are greater than the harmful effects it could have	☐	☐	☐	☐
7. Science and technology will help to eradicate poverty and famine in the world	☐	☐	☐	☐
8. Science and technology can solve nearly all problems	☐	☐	☐	☐
9. Science and technology are helping the poor	☐	☐	☐	☐
10. Science and technology are the cause of the environmental problems	☐	☐	☐	☐
11. A country needs science and technology to become developed	☐	☐	☐	☐
12. Science and technology benefit mainly the developed countries	☐	☐	☐	☐
13. Scientists follow the scientific method that always leads them to correct answers	☐	☐	☐	☐
14. We should always trust what scientists have to say	☐	☐	☐	☐
15. Scientists are neutral and objective	☐	☐	☐	☐
16. Scientific theories develop and change all the time	☐	☐	☐	☐

H. My out-of-school experiences
How often have you done this outside school?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)
I have ...

		Never	*Seldom*	*Some times*	*Often*
1.	tried to find the star constellations in the sky	☐	☐	☐	☐
2.	read my horoscope (telling future from the stars)	☐	☐	☐	☐
3.	read a map to find my way	☐	☐	☐	☐
4.	used a compass to find direction	☐	☐	☐	☐
5.	collected different stones or shells	☐	☐	☐	☐
6.	watched (not on TV) an animal being born	☐	☐	☐	☐
7.	cared for animals on a farm	☐	☐	☐	☐
8.	visited a zoo	☐	☐	☐	☐
9.	visited a science centre or science museum	☐	☐	☐	☐
10.	milked animals like cows, sheep or goats	☐	☐	☐	☐
11.	made dairy products like yoghurt, butter, cheese or ghee	☐	☐	☐	☐
12.	read about nature or science in books or magazines	☐	☐	☐	☐
13.	watched nature programmes on TV or in a cinema	☐	☐	☐	☐
14.	collected edible berries, fruits, mushrooms or plants	☐	☐	☐	☐
15.	participated in hunting	☐	☐	☐	☐
16.	participated in fishing	☐	☐	☐	☐
17.	planted seeds and watched them grow	☐	☐	☐	☐
18.	made compost of grass, leaves or garbage	☐	☐	☐	☐
19.	made an instrument (like a flute or drum) from natural materials	☐	☐	☐	☐
20.	knitted, weaved, etc	☐	☐	☐	☐
21.	put up a tent or shelter	☐	☐	☐	☐
22.	made a fire from charcoal or wood	☐	☐	☐	☐
23.	prepared food over a campfire, open fire or stove burner	☐	☐	☐	☐
24.	sorted garbage for recycling or for appropriate disposal	☐	☐	☐	☐
25.	cleaned and bandaged a wound	☐	☐	☐	☐
26.	seen an X-ray of a part of my body	☐	☐	☐	☐

		Never	Seldom	Some times	Often
27.	taken medicines to prevent or cure illness or infection	☐	☐	☐	☐
28.	taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)	☐	☐	☐	☐
29.	been to a hospital as a patient	☐	☐	☐	☐
30.	used binoculars	☐	☐	☐	☐
31.	used a camera	☐	☐	☐	☐
32.	made a bow and arrow, slingshot, catapult or boomerang	☐	☐	☐	☐
33.	used an air gun or rifle	☐	☐	☐	☐
34.	used a water pump or siphon	☐	☐	☐	☐
35.	made a model such as toy plane or boat etc	☐	☐	☐	☐
36.	used a science kit (like for chemistry, optics or electricity)	☐	☐	☐	☐
37.	used a windmill, watermill, waterwheel, etc	☐	☐	☐	☐
38.	recorded on video, DVD or tape recorder	☐	☐	☐	☐
39.	changed or fixed electric bulbs or fuses	☐	☐	☐	☐
40.	connected an electric lead to a plug etc.	☐	☐	☐	☐
41.	used a stopwatch	☐	☐	☐	☐
42.	measured the temperature with a thermometer	☐	☐	☐	☐
43.	used a measuring ruler, tape or stick	☐	☐	☐	☐
44.	used a mobile phone..	☐	☐	☐	☐
45.	sent or received an SMS (text message on mobile phone) ...	☐	☐	☐	☐
46.	searched the internet for information	☐	☐	☐	☐
47.	played computer games	☐	☐	☐	☐
48.	used a dictionary, encyclopaedia, etc. on a computer	☐	☐	☐	☐
49.	downloaded music from the internet......................................	☐	☐	☐	☐
50.	sent or received e-mail	☐	☐	☐	☐
51.	used a word processor on the computer	☐	☐	☐	☐
52.	opened a device (radio, watch, computer, telephone, etc.) to find out how it works	☐	☐	☐	☐

	Never	Seldom	Some times	Often
53. baked bread, pastry, cake, etc	☐	☐	☐	☐
54. cooked a meal	☐	☐	☐	☐
55. walked while balancing an object on my head	☐	☐	☐	☐
56. used a wheelbarrow	☐	☐	☐	☐
57. used a crowbar (jemmy)	☐	☐	☐	☐
58. used a rope and pulley for lifting heavy things	☐	☐	☐	☐
59. mended a bicycle tube	☐	☐	☐	☐
60. used tools like a saw, screwdriver or hammer	☐	☐	☐	☐
61. charged a car battery	☐	☐	☐	☐

I. Myself as a scientist

Assume that you are grown up and work as a scientist. You are free to do research that you find important and interesting. Write some sentences about what you would like to do as a researcher and why.

I would like to.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Because

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…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

J. 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.......☐

Appendix B.

Gender differences in science interests.

Mean values and standard deviation (SD) for girls and boys on the whole list of topics to learn about. The list is sorted by gender difference in ascending order. Positive difference (at the bottom part of the list) means that girls have higher responses. Items where there is a statistically significant ($p<0.05$) gender difference, p-values are in **boldface**.

Topics	Girls	Boys	Mean Difference	p-value
	Mean (SD)	Mean (SD)	(girls-boys)	
A44. Rockets, satellites and space travel	2.78 (1.08)	3.01 (1.08)	-0.23	**0.001**
A9. Sex and reproduction	2.71 (1.18)	2.92 (1.12)	-0.21	**0.003**
A45. The use of satellites for comm. and other purposes	3.05 (1.00)	3.25 (0.93)	-0.2	**0.001**
A47. How petrol and diesel engines work	2.84 (1.03)	3.03 (0.98)	-0.19	**0.003**
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.14 (0.95)	3.32 (0.89)	-0.18	**0.002**
C5. How things like radios and televisions work	3.25 (0.92)	3.41 (0.81)	-0.16	**0.005**
E40. Inventions and discoveries that have changed the world	2.78 (1.01)	2.93 (1.02)	-0.15	**0.029**
E3. The ozone layer and how it may be affected by humans	2.70 (1.09)	2.84 (1.09)	-0.14	**0.047**
E28. How to use and repair everyday electrical and mechanical equipment	3.05 (0.91)	3.19 (0.96)	-0.14	**0.022**
A1. Stars, planets and the universe	3.10 (1.01)	3.24 (0.96)	-0.14	**0.028**
A27. Brutal, dangerous and threatening animals	2.30 (1.08)	2.43 (1.14)	-0.13	0.066
A7. How the human body is built and functions	3.17 (1.01)	3.29 (0.93)	-0.12	**0.048**
A30. How the atom bomb functions	2.69 (1.06)	2.81 (1.06)	-0.12	0.082
E9. Sexually transmitted diseases and how to be protected against them	3.23 (1.04)	3.35 (0.96)	-0.12	0.065
A12. Cloning of animals	2.19 (1.06)	2.30 (1.12)	-0.11	0.124
E16. How to protect endangered species of animals	2.66 (1.01)	2.77 (1.04)	-0.11	0.112

A5. Clouds, rain and the weather	3.10 (1.00)	3.20 (0.95)	-0.1	0.106
C4. How cassette tapes, CDs and DVDs store and play sound and music	2.99 (1.03)	3.09 (1.00)	-0.1	0.137
E14. The possible radiation dangers of mobile phones and computers	2.96 (1.03)	3.06 (1.00)	-0.1	0.13
E39. How scientific ideas sometimes challenge religion, authority and tradition	2.64 (1.10)	2.74 (1.09)	-0.1	0.145
E18. Medicinal use of plants	3.08 (0.96)	3.17 (0.96)	-0.09	0.144
E38. Big blunders and mistakes in research and inventions	2.60 (1.10)	2.69 (1.09)	-0.09	0.196
A3. The inside of the earth	2.74 (1.13)	2.82 (1.14)	-0.08	0.224
A26. Epidemics and diseases causing large losses of life	2.59 (1.19)	2.67 (1.18)	-0.08	0.33
A31. Explosive chemicals	2.44 (1.03)	2.52 (1.13)	-0.08	0.289
E41. Very recent inventions and discoveries in science and technology	2.96 (0.98)	3.04 (0.97)	-0.08	0.196
A35. How to find my way and navigate by the stars	2.86 (1.03)	2.93 (1.07)	-0.07	0.31
E12. How alcohol and tobacco might affect the body	2.81 (1.12)	2.88 (1.16)	-0.07	0.386
A34. How it feels to be weightless in space	2.59 (1.09)	2.65 (1.09)	-0.06	0.363
E7. How to control epidemics and diseases	3.20 (0.94)	3.26 (0.96)	-0.06	0.337
E25. Plants in my area	3.02 (0.95)	3.08 (0.96)	-0.06	0.274
A20. How animals use colours to hide, attract or scare	2.51 (1.08)	2.56 (1.10)	-0.05	0.504
A24. Earthquakes and volcanoes	2.53 (1.14)	2.58 (1.20)	-0.05	0.493
C14. Ghosts and witches, and whether they may exist	2.12 (1.14)	2.17 (1.16)	-0.05	0.441
E10. How to perform first-aid and use basic medical equipment	3.18 (0.96)	3.23 (0.88)	-0.05	0.396
E27. Electricity, how it is produced and used in the home	3.36 (0.86)	3.41 (0.85)	-0.05	0.426
E37. Famous scientists and their lives	2.82 (1.04)	2.87 (1.02)	-0.05	0.407
A46. How X-rays, ultrasound, etc. are used in medicine	2.80 (1.11)	2.84 (1.06)	-0.04	0.58
C6. How mobile phones can send and receive messages	3.40 (0.84)	3.44 (0.82)	-0.04	0.518
E11. What we know about HIV/AIDS and how to control it	3.33 (0.96)	3.37 (0.97)	-0.04	0.55
E17. How to improve the harvest in gardens and farms	3.13 (0.94)	3.17 (0.92)	-0.04	0.526
E21. New sources of energy from the	3.02 (0.99)	3.06 (1.00)	-0.04	0.446

sun, wind, tides, waves, etc.				
E29. The first landing on the moon and the history of space exploration	3.01 (1.00)	3.05 (1.01)	-0.04	0.566
E30. How electricity has affected the development of our society	2.89 (1.04)	2.93 (1.00)	-0.04	0.474
A13. Animals in other parts of the world	2.75 (1.05)	2.78 (1.11)	-0.03	0.642
A23. How meteors, comets or asteroids may cause disasters on earth	2.63 (1.12)	2.66 (1.18)	-0.03	0.676
A28. Poisonous plants in my area	2.60 (1.14)	2.63 (1.17)	-0.03	0.655
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	2.81 (1.02)	2.84 (1.03)	-0.03	0.705
E15. How loud sound and noise may damage my hearing	2.69 (1.06)	2.72 (1.11)	-0.03	0.600
E33. Benefits and possible hazards of modern methods of farming	2.82 (0.94)	2.85 (1.00)	-0.03	0.658
A32. Biological and chemical weapons and what they do to the human body	2.80 (1.08)	2.82 (1.15)	-0.02	0.708
A33. The effect of strong electric shocks and lightning on the human body	2.79 (1.15)	2.81 (1.14)	-0.02	0.836
A42. How radiation from solariums and the sun might affect the skin	2.50 (1.09)	2.52 (1.13)	-0.02	0.76
E19. Organic and ecological farming without use of pesticides and artificial fertilizers	2.75 (1.06)	2.77 (1.09)	-0.02	0.693
E32. How gene technology can prevent diseases	2.93 (1.02)	2.95 (1.00)	-0.02	0.759
A43. How the ear can hear different sounds	3.20 (0.94)	3.21 (0.95)	-0.01	0.847
C1. How crude oil is converted to other materials, like plastics and textiles	2.89 (1.05)	2.90 (1.06)	-0.01	0.933
C9. Astrology and horoscopes, and whether the planets can influence human beings	2.75 (1.05)	2.76 (1.07)	-0.01	0.858
E4. The greenhouse effect and how it may be changed by humans	2.62 (1.08)	2.63 (1.03)	-0.01	0.844
E6. How technology helps us to handle waste, garbage and sewage	3.03 (0.99)	3.04 (1.01)	-0.01	0.835
E13. How different narcotics might affect the body	2.57 (1.08)	2.58 (1.06)	-0.01	0.812
E20. How energy can be saved or used in a more effective way	3.13 (0.92)	3.14 (0.96)	-0.01	0.872
E24. Animals in my area	2.85 (1.07)	2.86 (1.111)	-0.01	0.914
A40. How to exercise to keep the body fit and strong	3.44 (0.86)	3.44 (0.83)	0.00	0.902

C11. Life and death and the human soul	2.64 (1.18)	2.64 (1.13)	0.00	0.943
E36. Why scientists sometimes disagree	2.70 (1.07)	2.70 (1.10)	0.00	0.966
A41. Plastic surgery and cosmetic surgery	2.43 (1.08)	2.42 (1.14)	0.01	0.841
C7. How computers work	3.48 (0.88)	3.47 (0.85)	0.01	0.818
E23. How my body grows and matures	3.47 (0.84)	3.46 (0.80)	0.01	0.76
A37. What to eat to keep healthy and fit	3.47 (0.82)	3.45 (0.85)	0.02	0.772
C10. Unsolved mysteries in outer space	2.34 (0.98)	2.32 (1.05)	0.02	0.784
E22. How different sorts of food are produced, conserved and stored	3.07 (0.90)	3.05 (0.91)	0.02	0.784
A11. How babies grow and mature	3.07 (1.03)	3.04 (1.01)	0.03	0.614
E5. What can be done to ensure clean air and safe drinking water	3.48 (0.84)	3.45 (0.85)	0.03	0.617
E8. Cancer, what we know and how we can treat it	3.09 (0.98)	3.06 (0.99)	0.03	0.58
E34. Why religion and science sometimes are in conflict	2.77 (1.05)	2.74 (1.08)	0.03	0.603
A17. Atoms and molecules	3.13 (0.97)	3.09 (1.00)	0.04	0.62
A21. How different musical instruments produce different sounds	2.99 (1.03)	2.95 (1.05)	0.04	0.611
A2. Chemicals, their properties and how they react	2.72 (1.02)	2.67 (1.05)	0.05	0.407
A15. How plants grow and reproduce	3.26 (0.88)	3.21 (0.92)	0.05	0.415
E26. Detergents, soaps and how they work	2.87 (1.01)	2.82 (1.01)	0.05	0.5
A22. Black holes, supernovas and other spectacular objects in outer space	2.24 (1.07)	2.18 (1.09)	0.06	0.387
A29. Deadly poisons and what they do to the human body	2.81 (1.14)	2.75 (1.12)	0.06	0.474
A48. How a nuclear power plant functions	2.75 (1.06)	2.69 (1.04)	0.06	0.34
C13. Why we dream while we are sleeping, and what the dreams may mean	2.97 (1.07)	2.91 (1.04)	0.06	0.349
C17. Why we can see the rainbow	3.17 (0.92)	3.11 (0.93)	0.06	0.294
E2. How the sunset colours the sky	3.09 (0.92)	3.03 (0.98)	0.06	0.354
A16. How people, animals, plants and the environment depend on each other	3.21 (0.92)	3.14 (0.97)	0.07	0.233
A36. How the eye can see light and colours	3.37 (0.90)	3.30 (0.94)	0.07	0.202
C16. Why the stars twinkle and the sky is blue	3.08 (0.96)	3.01 (0.95)	0.07	0.22
A6. The origin and evolution of life on earth	2.82 (1.05)	2.74 (1.12)	0.08	0.25
E42. Phenomena that scientists still	2.76 (1.13)	2.68 (1.15)	0.08	0.028

cannot explain				
A8. Heredity, and how genes influence how we develop	2.57 (1.08)	2.47 (1.11)	0.1	0.144
A10. Birth control and contraception	2.84 (1.03)	2.73 (1.08)	0.11	0.104
C8. The possibility of life outside earth	2.68 (1.06)	2.57 (1.06)	0.11	0.113
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	2.35 (1.05)	2.24 (1.06)	0.11	0.123
C15. Thought transference, mind-reading, sixth sense, intuition, etc.	2.75 (1.06)	2.64 (1.05)	0.11	0.104
A4. How mountains, rivers and oceans develop and change	2.97 (1.00)	2.85 (1.09)	0.12	0.093
A25. Tornados, hurricanes and cyclones	2.28 (1.05)	2.15 (1.01)	0.13	0.061
A38. Eating disorders like anorexia or bulimia	2.31 (1.05)	2.18 (1.05)	0.13	0.088
E31. Biological and human aspects of abortion	2.75 (1.13)	2.62 (1.17)	0.13	0.076
E35. Risks and benefits of food additives	2.80 (1.05)	2.67 (1.05)	0.13	**0.045**
A14. Dinosaurs, how they lived and why they died out	2.34 (1.13)	2.20 (1.14)	0.14	0.069
A19. Light around us that we cannot see (infrared, ultraviolet)	2.69 (1.08)	2.55 (1.19)	0.14	0.057
E1. Symmetries and patterns in leaves and flowers	2.74 (1.11)	2.59 (1.08)	0.15	**0.031**
A18. How radioactivity affects the human body	2.64 (1.07)	2.47 (1.15)	0.17	**0.027**
C18. Properties of gems and crystals and how these are used for beauty	2.76 (1.05)	2.53 (1.05)	0.23	**0.001**
A39. The ability of lotions and creams to keep the skin young	2.52 (1.14)	2.26 (1.12)	0.26	**0.000**

Appendix C.

Urban/rural differences in science interests.

Mean values and standard deviation (SD) for urban and rural pupils on the whole list of topics to learn about. The list is sorted by the urban-rural difference in ascending order. Items where there is a statistically significant ($p<0.05$) difference, p-values are in **boldface**. Positive values (items at the bottom of the list) indicate that responses are higher in urban areas

	Urban	Rural	Mean Difference	
Topics	Mean(SD)	Mean(SD)	Urban-Rural	p-value
E19. Organic and ecological farming without use of pesticides and artificial fertilizers	2.61 (1.08)	2.99 (1.00)	-0.38	**0.000**
E38. Big blunders and mistakes in research and inventions	2.49 (1.06)	2.87 (1.10)	-0.38	**0.000**
A35. How to find my way and navigate by the stars	2.75 (1.05)	3.12 (1.00)	-0.37	**0.000**
A41. Plastic surgery and cosmetic surgery	2.28 (1.06)	2.63 (1.20)	-0.35	**0.000**
C15. Thought transference, mind-reading, sixth sense, intuition, etc.	2.55 (1.00)	2.88 (1.10)	-0.33	**0.000**
A25. Tornados, hurricanes and cyclones	2.09 (0.98)	2.38 (1.10)	-0.29	**0.000**
E42. Phenomena that scientists still cannot explain	2.60 (1.98)	2.88 (1.10)	-0.28	**0.000**
A22. Black holes, supernovas and other spectacular objects in outer space	2.12 (1.02)	2.37 (1.20)	-0.25	**0.001**
E40. Inventions and discoveries that have changed the world	2.76 (1.03)	3.01 (1.00)	-0.25	**0.000**
C9. Astrology and horoscopes, and whether the planets can influence human beings	2.66 (1.03)	2.88 (1.10)	-0.22	**0.002**
A8. Heredity, and how genes influence how we develop	2.43 (1.06)	2.64 (1.10)	-0.21	**0.003**
E3. The ozone layer and how it may be affected by humans	2.7 (1.08)	2.90 (1.10)	-0.2	**0.011**
A26. Epidemics and diseases causing large losses of life	2.56 (1.18)	2.75 (1.20)	-0. 19	**0.005**

E1. Symmetries and patterns in leaves and flowers	.58 (1.09)	2.77 (1.10)	-0.19	**0.008**
A46. How X-rays, ultrasound, etc. are used in medicine	2.75 (1.09)	2.92 (1.10)	-0.17	**0.017**
A6. The origin and evolution of life on earth	2.71 (1.07)	2.87 (1.10)	-0.16	**0.015**
C1. How crude oil is converted to other materials, like plastics and textiles	2.83 (1.08)	2.99 (1.00)	-0.16	**0.024**
E41. Very recent inventions and discoveries in science and technology	2.94 (0.97)	3.10 (1.00)	-0.16	**0.020**
A33. The effect of strong electric shocks and lightning on the human body	2.74 (1.16)	2.89 (1.10)	-0.15	**0.019**
E16. How to protect endangered species of animals	2.66 (1.00)	2.81 (1.10)	-0.15	**0.013**
E18. Medicinal use of plants	3.06 (0.97)	3.21 (1.00)	-0.15	**0.017**
E29. The first landing on the moon and the history of space exploration	2.97 (1.02)	3.12 (1.00)	-0.15	0.067
A28. Poisonous plants in my area	2.56 (1.17)	2.70 (1.10)	-0.14	0.052
E14. The possible radiation dangers of mobile phones and computers	2.96 (1.03)	3.10 (1.00)	-0.14	**0.031**
E22. How different sorts of food are produced, conserved and stored	3.00 (0.90)	3.14 (0.90)	-0.14	**0.017**
E39. How scientific ideas sometimes challenge religion, authority and tradition	2.64 (1.11)	2.78 (1.10)	-0.14	**0.050**
A14. Dinosaurs, how they lived and why they died out	2.21 (1.11)	2.34 (1.20)	-0.13	0.122
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	2.24 (1.02)	2.37 (1.10)	-0.13	0.096
A30. How the atom bomb functions	2.71 (1.07)	2.83 (1.10)	-0.12	0.080
A34. How it feels to be weightless in space	2.58 (1.09)	2.70 (1.10)	-0.12	0.088
C18. Properties of gems and crystals and how these are used for beauty	2.59 (1.08)	2.71 (1.00)	-0.12	0.062
E4. The greenhouse effect and how it may be changed by humans	2.58 (1.05)	2.70 (1.10)	-0.12	0.071
E30. How electricity has affected the development of our society	2.86 (1.01)	2.98 (1.00)	-0.12	0.057
E21. New sources of energy from the sun, wind, tides, waves, etc.	2.99 (0.99)	3.11 (1.00)	-0.12	0.106

E17. How to improve the harvest in gardens and farms	3.11 (0.94)	3.22 (0.90)	-0.11	0.158
A15. How plants grow and reproduce	3.19 (0.90)	3.30 (0.90)	-0.11	0.125
E24. Animals in my area	2.81 (1.10)	2.92 (1.10)	-0.11	0.108
A27. Brutal, dangerous and threatening animals	2.33 (1.09)	2.43 (1.10)	-0.10	0.155
A38. Eating disorders like anorexia or bulimia	2.21 (1.01)	2.31 (1.10)	-0.10	0.082
A9. Sex and reproduction	2.79 (1.16)	2.88 (1.20)	-0.09	0.209
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.20 (0.93)	3.29 (0.90)	-0.09	0.127
A19. Light around us that we cannot see (infrared, ultraviolet)	2.59 (1.13)	2.67 (1.20)	-0.08	0.287
A23. How meteors, comets or asteroids may cause disasters on earth	2.61 (1.17)	2.69 (1.10)	-0.08	0.277
A29. Deadly poisons and what they do to the human body	2.75 (1.15)	2.83 (1.10)	-0.08	0.184
E20. How energy can be saved or used in a more effective way	3.10 (0.94)	3.18 (0.90)	-0.08	0.230
E26. Detergents, soaps and how they work	2.81 (1.01)	2.89 (1.00)	-0.08	0.213
E35. Risks and benefits of food additives	2.70 (1.03)	2.78 (1.10)	-0.08	0.233
A10. Birth control and contraception	2.75 (1.00)	2.82 (1.10)	-0.07	0.338
A42. How radiation from solariums and the sun might affect the skin	2.49 (1.11)	2.56 (1.10)	-0.07	0.340
E28. How to use and repair everyday electrical and mechanical equipment	3.10 (0.95)	3.17 (0.90)	-0.07	0.337
A4. How mountains, rivers and oceans develop and change	2.88 (1.04)	2.94 (1.10)	-0.06	0.385
C6. How mobile phones can send and receive messages	3.40 (0.86)	3.46 (0.80)	-0.06	0.401
C11. Life and death and the human soul	2.62 (1.15)	2.68 (1.20)	-0.06	0.262
E15. How loud sound and noise may damage my hearing	2.68 (1.10)	2.74 (1.10)	-0.06	0.449
A21. How different musical instruments produce different sounds	2.95 1.03)	3.01 (1.10)	-0.06	0.399
A47. How petrol and diesel engines work	2.92 (1.01)	2.97 (1.00)	-0.05	0.42
A45. The use of satellites for communication and other purposes	3.14 (0.97)	3.19 (1.00)	-0.05	0.378

C16. Why the stars twinkle and the sky is blue	3.02 (0.97)	3.07 (0.90)	-0.04	0.559
A13. Animals in other parts of the world	2.75 (1.07)	2.79 (1.10)	-0.04	0.510
A16. How people, animals, plants and the environment depend on each other	3.16 (0.95)	3.20 (1.00)	-0.04	0.559
A48. How a nuclear power plant functions	2.70 (1.02)	2.74 (1.10)	-0.04	0.578
E13. How different narcotics might affect the body	2.56 (1.02)	2.60 (1.10)	-0.04	0.534
E36. Why scientists sometimes disagree	2.68 (1.11)	2.72 (1.10)	-0.04	0.562
A3. The inside of the earth	2.77 (1.13)	2.80 (1.20)	-0.03	0.684
A44. Rockets, satellites and space travel	2.89 (1.10)	2.92 (1.10)	-0.03	0.684
E25. Plants in my area	3.04 (0.98)	3.07 (0.90)	-0.03	0.681
A11. How babies grow and mature	3.05 (1.02)	3.07 (1.00)	-0.02	0.761
C10. Unsolved mysteries in outer space	2.32 (1.00)	2.34 (1.00)	-0.02	0.791
E33. Benefits and possible hazards of modern methods of farming	2.83 (0.95)	2.85 (1.00)	-0.02	0.761
A24. Earthquakes and volcanoes	2.55 (1.16)	2.56 (1.20)	-0.01	0.897
A31. Explosive chemicals	2.48 (1.05)	2.48 (1.10)	-0.00	0.897
C4. How cassette tapes, CDs and DVDs store and play sound and music	3.04 (1.00)	3.04 (1.10)	0.00	0.952
E27. Electricity, how it is produced and used in the home	3.39 (0.84)	3.39 (0.90)	0.00	0.999
E11. What we know about HIV/AIDS and how to control it	3.36 (0.98)	3.35 (1.00)	0.01	0.922
E2. How the sunset colours the sky	3.06 (0.95)	3.05 (1.00)	0.01	0.868
A12. Cloning of animals	2.26 (1.04)	2.23 (1.20)	0.03	0.876
E37. Famous scientists and their lives	2.86 (1.02)	2.83 (1.00)	0.03	0.639
C5. How things like radios and televisions work	3.35 0.86))	3.32 (0.90)	0.03	0.608
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	2.84 (1.01)	2.80 (1.00)	0.04	0.552
E23. How my body grows and matures	3.48 (0.78)	3.44 (0.90)	0.04	0.708
A7. How the human body is built and functions	3.26 (0.96)	3.20 (1.00)	0.06	0.575
A20. How animals use colours to hide, attract or scare	2.56 (1.10)	2.50 (1.10)	0.06	0.360
E32. How gene technology can prevent diseases	2.96 (0.99)	2.90 (1.00)	0.06	0.376

E31. Biological and human aspects of abortion	2.71 (1.12)	2.64 (1.20)	0.07	0.396
E34. Why religion and science sometimes are in conflict	2.78 (1.03)	2.71 (1.10)	0.07	0.172
A40. How to exercise to keep the body fit and strong	3.47 (0.83)	3.40 (0.90)	0.07	0.331
A37. What to eat to keep healthy and fit	3.49 (0.80)	3.41 (0.90)	0.08	0.341
C14. Ghosts and witches, and whether they may exist	2.18 (1.15)	2.10 (1.20)	0.08	0.145
E7. How to control epidemics and diseases	3.27 (0.93)	3.18 (1.00)	0.09	0.261
A2. Chemicals, their properties and how they react	2.73 (1.00)	2.63 (1.10)	0.10	0.122
A18. How radioactivity affects the human body	2.58 (1.12)	2.48 (1.10)	0.10	0.166
C17. Why we can see the rainbow	3.18 (0.92)	3.08 (0.90)	0.10	0.143
E5. What can be done to ensure clean air and safe drinking water	3.51 (0.78)	3.40 (0.90)	0.11	0.083
A1. Stars, planets and the universe	3.22 (0.95)	3.11 (1.00)	0.11	0.087
A5. Clouds, rain and the weather	3.20 (0.92)	3.09 (1.10)	0.11	0.177
A36. How the eye can see light and colours	3.38 (0.89)	3.25 (1.00)	0.13	0.053
C7. How computers work	3.52 (0.84)	3.39 (0.90)	0.13	0.057
E9. Sexually transmitted diseases and how to be protected against them	3.35 (0.99)	3.22 (1.00)	0.13	**0.029**
E12. How alcohol and tobacco might affect the body	2.90 (1.13)	2.77 (1.20)	0.13	**0.020**
A43. How the ear can hear different sounds	3.26 (0.92)	3.12 (1.00)	0.14	0.069
E8. Cancer, what we know and how we can treat it	3.13 (0.97)	2.99 (1.00)	0.14	**0.028**
A17. Atoms and molecules	3.17 (0.95)	3.03 (1.00)	0.14	**0.025**
E6. How technology helps us to handle waste, garbage and sewage	3.10 (0.97)	2.95 (1.00)	0.15	**0.030**
C8. The possibility of life outside earth	2.69 (1.03)	2.52 (1.10)	0.17	**0.020**
E10. How to perform first-aid and use basic medical equipment	3.28 (0.88)	3.08 (1.00)	0.20	**0.015**
A39. The ability of lotions and creams to keep the skin young	2.47 (1.09)	2.26 (1.20)	0.21	**0.001**
A32. Biological and chemical weapons and what they do to the human body	2.90 (1.09)	2.68 (1.20)	0.22	**0.004**
C13. Why we dream while we are sleeping, and what the dreams may mean	3.04 (1.03)	2.79 1.10)	0.25	**0.005**

Appendix D.

Cluster of topics into science subject areas with Cronbach's alphas

Biology: Health Science (Health Risk). Cronbach's Alpha = 0.698
A18. How radioactivity affects the human body
A26. Epidemics and diseases causing large losses of life
A29. Deadly poisons and what they do to the human body
A32. Biological and chemical weapons and what they do to the human body
A42. How radiation from solariums and the sun might affect the skin
E13. How different narcotics might affect the body
E14. The possible radiation dangers of mobile phones and computers
E15. How loud sound and noise may damage my hearing

Biology: Health Science (Health Enhancement). Cronbach's Alpha = 0.724
A37. What to eat to keep healthy and fit
A38. Eating disorders like anorexia or bulimia
A40. How to exercise to keep the body fit and strong
A46. How X-rays, ultrasound, etc. are used in medicine
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are
E7. How to control epidemics and diseases
E8. Cancer, what we know and how we can treat it
E9. Sexually transmitted diseases and how to be protected against them
E10. How to perform first-aid and use basic medical equipment
E11. What we know about HIV/AIDS and how to control it
E32. How gene technology can prevent diseases
E35. Risks and benefits of food additives

Biology: Human Biology. Cronbach's Alpha = 0.736
A7. How the human body is built and functions
A8. Heredity, and how genes influence how we develop
A9. Sex and reproduction
A10. Birth control and contraception
A11. How babies grow and mature
A18. How radioactivity affects the human body
A26. Epidemics and diseases causing large losses of life
E8. Cancer, what we know and how we can treat it
E9. Sexually transmitted diseases and how to be protected against them
E10. How to perform first-aid and use basic medical equipment

E11. What we know about HIV/AIDS and how to control it
E13. How different narcotics might affect the body
E14. The possible radiation dangers of mobile phones and computers
E15. How loud sound and noise may damage my hearing
E23. How my body grows and matures
A16. How people, animals, plants and the environment depend on each other

Biology: Botany. Cronbach's Alpha = 0.551
A16. How people, animals, plants and the environment depend on each other
A28. Poisonous plants in my area
E1. Symmetries and patterns in leaves and flowers
E18. Medicinal use of plants
E19. Organic and ecological farming without use of pesticides and artificial fertilizers
E25. Plants in my area

Biology: Zoology. Cronbach's Alpha = 0.518
A12. Cloning of animals
A13. Animals in other parts of the world
A16. How people, animals, plants and the environment depend on each other
A20. How animals use colours to hide, attract or scare
A27. Brutal, dangerous and threatening animals
E24. Animals in my area

Agricultural Science. Cronbach's Alpha = 0.501
A15. How plants grow and reproduce
E17. How to improve the harvest in gardens and farms
E16. How to protect endangered species of animals
E19. Organic and ecological farming without use of pesticides and artificial fertilizers
E33. Benefits and possible hazards of modern methods of farming

Chemistry (content). Cronbach's Alpha = 0.572
A2. Chemicals, their properties and how they react
A17. Atoms and molecules
A30. How the atom bomb functions
A31. Explosive chemicals
A32. Biological and chemical weapons and what they do to the human body

Chemistry (context). Cronbach's Alpha = 0.533
A2. Chemicals, their properties and how they react
A47. How petrol and diesel engines work

A48. How a nuclear power plant functions
C1. How crude oil is converted to other materials, like plastics and textiles
E26. Detergents, soaps and how they work

Physics (content). Cronbach's Alpha = 0.781
A18. How radioactivity affects the human body
A19. Light around us that we cannot see (infrared, ultraviolet)
A21. How different musical instruments produce different sounds
A33. The effect of strong electric shocks and lightning on the human body
A34. How it feels to be weightless in space
A36. How the eye can see light and colours
A43. How the ear can hear different sounds
A44. Rockets, satellites and space travel
A45. The use of satellites for communication and other purposes
A46. How X-rays, ultrasound, etc. are used in medicine
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)
C16. Why the stars twinkle and the sky is blue
C17. Why we can see the rainbow
E2. How the sunset colours the sky
E20. How energy can be saved or used in a more effective way
E21. New sources of energy from the sun, wind, tides, waves, etc.

Physics (context). Cronbach's Alpha = 0.771
A30. How the atom bomb functions
A33. The effect of strong electric shocks and lightning on the human body
A43. How the ear can hear different sounds
A44. Rockets, satellites and space travel
A45. The use of satellites for communication and other purposes
A48. How a nuclear power plant functions
C4. How cassette tapes, CDs and DVDs store and play sound and music
C16. Why the stars twinkle and the sky is blue
C17. Why we can see the rainbow
E2. How the sunset colours the sky
E20. How energy can be saved or used in a more effective way
E21. New sources of energy from the sun, wind, tides, waves, etc.
E27. Electricity, how it is produced and used in the home
E30. How electricity has affected the development of our society

Environmental Education. Cronbach's Alpha = 0.687
E3. The ozone layer and how it may be affected by humans
E4. The greenhouse effect and how it may be changed by humans

E5. What can be done to ensure clean air and safe drinking water
E6. How technology helps us to handle waste, garbage and sewage
E16. How to protect endangered species of animals
E19. Organic and ecological farming without use of pesticides and artificial fertilizers
E20. How energy can be saved or used in a more effective way
E21. New sources of energy from the sun, wind, tides, waves, etc.
E33. Benefits and possible hazards of modern methods of farming

Technology Education. Cronbach's Alpha = 0.765
A44. Rockets, satellites and space travel
A45. The use of satellites for communication and other purposes
A47. How petrol and diesel engines work
A48. How a nuclear power plant functions
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)
C4. How cassette tapes, CDs and DVDs store and play sound and music
C5. How things like radios and televisions work
C6. How mobile phones can send and receive messages
C7. How computers work
E6. How technology helps us to handle waste, garbage and sewage

Appendix E.

Gender differences in pupils' views about environmental challenges

Mean values and standard deviation (SD) for girls and boys on the whole list of experiences. The list is sorted by gender difference in ascending order. Items where there is a statistically significant ($p<0.05$) difference, p-values are in **boldface**. Positive difference (at the bottom part of the list) means that girls have higher responses

Statements on environmental challenges	Girls Mean(SD)	Boys Mean(SD)	Mean Difference Girls-Boys	p-value
D14. I am optimistic about the future	2.97 (1.02)	3.22 (1.12)	-0.25	**0.001**
D2. Environmental problems make the future of the world look bleak and hopeless	2.16 (1.14)	2.38 (1.16)	-0.22	**0.002**
D3. Environmental problems are exaggerated	2.33 (0.99)	2.48 (1.13)	-0.15	**0.031**
D1. Threats to the environment are not my business	2.97 (1.17)	3.07 (1.12)	-0.10	0.156
D6. I can personally influence what happens with the environment	2.77 (1.02)	2.86 (1.12)	-0.09	0.214
D17. Nearly all human activity is damaging for the environment	2.77 (1.05)	2.82 (1.13)	-0.05	0.467
D13. Environmental problems should be left to the experts	2.14 (1.07)	2.18 (1.14)	-0.04	0.608
D18. The natural world is sacred and should be left in peace	3.11 (1.08)	3.1 (1.13)	0.01	0.889
D9. Environmental problems can be solved without big changes in our way of living	2.59 (1.21)	2.52 (1.19)	0.07	0.400

D5. I am willing to have environmental problems solved even if this means sacrificing many goods	2.88 (1.1)	2.75 (1.18)	0.13	0.072
D11. It is the responsibility of the rich countries to solve the environmental problems of the world	2.55 (1.24)	2.42 (1.25)	0.13	0.120
D16. It is right to use animals in medical experiments if this can save human lives	3.03 (1.08)	2.87 (1.2)	0.16	**0.027**
D4. Science and technology can solve all environmental problems	3.3 (1.01)	3.11 (1.13)	0.19	**0.007**
D15. Animals should have the same right to life as people	2.49 (1.23)	2.25 (1.26)	0.24	**0.002**
D7. We can still find solutions to our environmental problems	3.42 (0.92)	3.09 (1.04)	0.33	**0.000**
D12. I think each of us can make a significant contribution to environmental protection	3.37 (0.88)	3.01 (1.09)	0.36	**0.000**
D10. People should care more about protection of the environment	3.47 (0.87)	3.08 (1.09)	0.39	**0.000**
D8. People worry too much about environmental problems	3.16 (1.05)	2.75 (1.17)	0.41	**0.000**

Appendix F.

Gender differences in pupils' relationship with school science

Mean values and standard deviation (SD) for girls and boys on the whole list of experiences. The list is sorted by gender difference in ascending order. Items where there is a statistically significant (p<0.05) difference, p-values are in **boldface**. Positive difference (at the bottom part of the list) means that girls have higher responses

Statements on science classes	Girls	Boys	Mean Difference	
	Mean(SD)	Mean(SD)	Girls-Boys	p-value
F16. I would like to get a job in technology	3.29(0.97)	3.47(0.87)	-0.18	**0.002**
F4. School science has opened my eyes to new and exciting jobs	3.34(0.97)	3.49(0.88)	-0.16	**0.008**
F1. School science is a difficult subject	2.63(1.30)	2.74(1.30)	-0.11	0.193
F9. School science has made me more critical and sceptical	3.13(0.98)	3.23(0.92)	-0.11	0.089
F2. School science is interesting	3.48(0.9)	3.59(0.8)	-0.10	**0.051**
F12. School science has shown me the importance of science for our way of living	3.47(0.9)	3.56(0.81)	-0.09	0.083
F14. I would like to become a scientist	3.36(0.92)	3.44(0.92)	-0.08	0.189
F13. School science has taught me how to take better care of my health	3.54(0.84)	3.6(0.81)	-0.06	0.220
F8. I think that the science I learn at school will improve my career chances	3.39(0.89)	3.44(0.87)	-0.05	0.372
F6. I think everybody should learn science at school	3.37(0.99)	3.42(0.95)	-0.04	0.471
F15. I would like to have as much science as possible at school	3.33(0.93)	3.37(0.89)	-0.04	0.474
F11. School science has increased my appreciation of nature	3.25(0.97)	3.28(0.95)	-0.03	0.679

F5. I like school science better than most other subjects	3.17(1.03)	3.18(1.04)	-0.01	0.877
F7. The things that I learn in science at school will be helpful in my everyday life	3.56(0.79)	3.56(0.8)	-0.01	0.893
F3. School science is rather easy for me to learn	3.33(0.97)	3.33(0.99)	0.00	0.968
F10. School science has increased my curiosity about things we cannot yet explain	3.1(0.98)	3.04(1.06)	0.06	0.394

Appendix G.

Gender differences in opinion about S&T

Mean values and standard deviation (SD) for girls and boys on the whole list of experiences. The list is sorted by gender difference in ascending order. Items where there is a statistically significant ($p<0.05$) difference, p-values are in **boldface**. Positive difference (at the bottom part of the list) means that girls have higher responses

Statements (items) on science and technology	Girls	Boys	Mean Difference	
	Mean(SD)	Mean(SD)	Girls-Boys	p-value
G1. Science and technology are important for society	3.47 (0.9)	3.64 (0.76)	-0.17	**0.001**
G6. The benefits of science are greater than the harmful effects it could have	3.02 (1.01)	3.14 (0.98)	-0.12	0.069
G10. Science and technology are the cause of the environmental problems	2.75 (1.21)	2.84 (1.22)	-0.09	0.223
G15. Scientists are neutral and objective	2.83 (1.05)	2.91 (1.06)	-0.07	0.283
G5. New technologies will make work more interesting	3.3 (0.88)	3.37 (0.85)	-0.07	0.216
G8. Science and technology can solve nearly all problems	2.89 (1.1)	2.95 (1.05)	-0.06	0.404
G4. Science and technology make our lives healthier, easier and more comfortable	3.41 (0.91)	3.44 (0.9)	-0.03	0.563
G11. A country needs science and technology to become developed	3.35 (0.89)	3.38 (0.91)	-0.03	0.653
G3. Thanks to science and technology, there will be greater opportunities for future generations	3.31 (0.93)	3.32 (0.88)	-0.01	0.822
G9. Science and technology are helping the poor	2.69 (1.18)	2.7 (1.19)	-0.01	0.876
G2. Science and technology will find cures to diseases such	3.22 (1.05)	3.22 (1.07)	0.00	0.946

as HIV/AIDS, cancer, etc.				
G16. Scientific theories develop and change all the time	2.96 (1.08)	2.94 (1.08)	0.02	0.798
G13. Scientists follow the scientific method that always leads them to correct answers	3.15 (0.97)	3.11 (1.01)	0.03	0.614
G7. Science and technology will help to eradicate poverty and famine in the world	2.94 (1.05)	2.88 (1.09)	0.06	0.384
G12. Science and technology benefit mainly the developed countries	2.96 (1.08)	2.89 (1.13)	0.08	0.287
G14. We should always trust what scientists have to say	2.97 (1.02)	2.85 (1.07)	0.12	0.066

Appendix H.

Urban/rural differences in opinion about S&T

Mean values and standard deviation (SD) for urban and rural pupils on the whole list of topics to learn about. The list is sorted by the urban-rural difference in ascending order. Items where there is a statistically significant ($p<0.05$) difference, p-values are in **boldface**. Positive values (items at the bottom of the list) indicate that responses are higher in urban areas

Statements (items) on science and technology	Urban	Rural	Mean Difference	
	Mean(SD)	Mean(SD)	Urban-Rural	p-value
G15. Scientists are neutral and objective	2.8 (1.03)	2.98 (1.08)	-0.18	**0.008**
G9. Science and technology are helping the poor	2.63 (1.17)	2.8 (1.2)	-0.17	**0.021**
G16. Scientific theories develop and change all the time	2.93 (1.07)	2.99 (1.09)	-0.06	0.343
G1. Science and technology are important for society	3.55 (0.83)	3.58 (0.84)	-0.03	0.643
G8. Science and technology can solve nearly all problems	2.91 (1.07)	2.94 (1.08)	-0.03	0.596
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	3.21 (1.07)	3.23 (1.05)	-0.02	0.831
G5. New technologies will make work more interesting	3.33 (0.83)	3.34 (0.91)	-0.01	0.778
G6. The benefits of science are greater than the harmful effects it could have	3.08 (0.97)	3.09 (1.04)	-0.01	0.850
G11. A country needs science and technology to become developed	3.36 (0.89)	3.37 (0.92)	-0.01	0.849
G7. Science and technology will help to eradicate poverty and famine in the world	2.9 (1)	2.9 (1.17)	0.00	0.979
G4. Science and technology make our lives healthier, easier and more comfortable	3.44 (0.89)	3.4 (0.93)	0.04	0.499

G3. Thanks to science and technology, there will be greater opportunities for future generations	3.35 (0.86)	3.26 (0.95)	0.09	0.134
G14. We should always trust what scientists have to say	2.95 (1.01)	2.84 (1.1)	0.11	0.137
G13. Scientists follow the scientific method that always leads them to correct answers	3.19 (0.94)	3.04 (1.05)	0.15	**0.023**
G10. Science and technology are the cause of the environmental problems	2.92 (1.19)	2.62 (1.23)	0.30	**0.000**
G12. Science and technology benefit mainly the developed countries	3.1 (1)	2.67 (1.2)	0.43	**0.000**

Appendix I.

Gender differences in out-of-school experiences.

Mean values and standard deviation (SD) for girls and boys on the whole list of experiences. The list is sorted by gender difference in ascending order. Items where there is a statistically significant ($p<0.05$) difference, p-values are in **boldface**. Positive difference (at the bottom part of the list) means that girls have higher responses

	Girls	Boys	Mean Difference	
Out-of-school activities	Mean(SD)	Mean(SD)	Girls-Boys	p-value
H32. Made a bow and arrow, slingshot, catapult or boomerang	2.04 (1.08)	2.48 (1.1)	-0.45	**0.000**
H60. Used tools like a saw, screwdriver or hammer	2.51 (1.07)	2.93 (0.96)	-0.42	**0.000**
H56. Used a wheelbarrow	2.41 (1.08)	2.74 (1)	-0.33	**0.000**
H39. Changed or fixed electric bulbs or fuses	2.23 (1.12)	2.56 (1.15)	-0.33	**0.000**
H59. Mended a bicycle tube	2 00 (1.14)	2.32 (1.14)	-0.32	**0.000**
H57. Used a crowbar (jemmy)	2.07 (1.08)	2.38 (1.03)	-0.31	**0.000**
H15. Participated in hunting	1.81 (1.05)	2.12 (1.1)	-0.31	**0.000**
H19. Made an instrument (like a flute or drum) from natural materials	2.43 (1.09)	2.72 (0.98)	-0.29	**0.000**
H21. Put up a tent or shelter	2.25 (1.13)	2.51 (1.11)	-0.27	**0.000**
H16. Participated in fishing	1.93 (1.11)	2.18 (1.15)	-0.25	**0.001**
H52. Opened a device (radio, watch, computer, telephone, etc.) to find out how it works	2.67 (1.16)	2.87 (1.1)	-0.20	**0.006**
H35. Made a model such as toy plane or boat etc	2.35 (1.1)	2.55 (1.05)	-0.20	**0.004**
H7. Cared for animals on a farm	2.46 (1.16)	2.66 (1.15)	-0.20	**0.008**
H61. Charged a car battery	1.97 (1.19)	2.14 (1.25)	-0.18	**0.022**
H38. Recorded on video, DVD or tape recorder	2.43 (1.14)	2.56 (1.1)	-0.14	0.059
H31. Used a camera	2.18 (1.14)	2.3 (1.14)	-0.12	0.098
H17. Planted seeds and watched them grow	2.79 (1.03)	2.91 (1)	-0.12	0.069

H1. Tried to find the star constellations in the sky	2.15 (1.14)	2.25 (1.15)	-0.10	0.164
H40. Connected an electric lead to a plug etc.	2.23 (1.17)	2.31 (1.22)	-0.09	0.250
H14. Collected edible berries, fruits, mushrooms or plants	2.74 (1.03)	2.83 (1.05)	-0.09	0.192
H58. Used a rope and pulley for lifting heavy things	2.19 (1.16)	2.27 (1.12)	-0.08	0.242
H33. Used an air gun or rifle	1.85 (1.09)	1.93 (1.11)	-0.08	0.237
H24. Sorted garbage for recycling or for appropriate disposal	2.06 (1.05)	2.13 (1.12)	-0.07	0.312
H3. Read a map to find my way	2.46 (1.16)	2.52 (1.23)	-0.06	0.409
H25. Cleaned and bandaged a wound	2.57 (1.04)	2.63 (1.03)	-0.06	0.349
H49. Downloaded music from the internet	2.08 (1.14)	2.14 (1.16)	-0.06	0.404
H10. Milked animals like cows, sheep or goats	2.19 (1.2)	2.24 (1.2)	-0.05	0.501
H46. Searched the internet for information	2.13 (1.14)	2.18 (1.17)	-0.05	0.543
H55. Walked while balancing an object on my head	2.67 (1.13)	2.71 (1.09)	-0.04	0.589
H5. Collected different stones or shells	2.33 (1.11)	2.36 (1.1)	-0.03	0.632
H47. Played computer games	2.59 (1.13)	2.63 (1.11)	-0.03	0.642
H41. Used a stopwatch	2.07 (1.14)	2.1 (1.17)	-0.03	0.662
H28. Taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)	2.55 (1.06)	2.58 (1.05)	-0.03	0.670
H12. Read about nature or science in books or magazines	2.97 (1.01)	3 (0.97)	-0.03	0.672
H36. Used a science kit (like for chemistry, optics or electricity)	2.2 (1.13)	2.22 (1.2)	-0.03	0.723
H6. Watched (not on TV) an animal being born	2.57 (1.07)	2.59 (1.07)	-0.02	0.747
H4. Used a compass to find direction	2.6 (1.24)	2.62 (1.26)	-0.02	0.782
H48. Used a dictionary, encyclopaedia, etc. on a computer	2.27 (1.21)	2.29 (1.26)	-0.02	0.786
H27. Taken medicines to prevent or cure illness or infection	3.11 (0.95)	3.13 (0.93)	-0.01	0.861

H2. Read my horoscope (telling future from the stars)	2.16 (1.12)	2.17 (1.15)	-0.01	0.886
H22. Made a fire from charcoal or wood	3.13 (1.05)	3.14 (1.02)	-0.01	0.909
H8. Visited a zoo	2.43 (1.14)	2.44 (1.14)	-0.01	0.945
H26. Seen an X-ray of a part of my body	2.22 (1.19)	2.22 (1.19)	0.00	0.982
H18. Made compost of grass, leaves or garbage	2.42 (1.09)	2.42 (1.14)	0.00	0.964
H50. Sent or received e-mail	2.19 (1.15)	2.18 (1.17)	0.01	0.878
H13. Watched nature programmes on TV or in a cinema	2.92 (1.01)	2.91 (0.99)	0.01	0.856
H30. Used binoculars	1.9 (1.04)	1.89 (1.1)	0.01	0.847
H44. Used a mobile phone	2.33 (1.22)	2.32 (1.21)	0.01	0.854
H43. Used a measuring ruler, tape or stick	2.98 (1.03)	2.95 (1.04)	0.03	0.600
H11. Made dairy products like yoghurt, butter, cheese or ghee	2.17 (1.18)	2.13 (1.18)	0.04	0.598
H51. Used a word processor on the computer	2.16 (1.17)	2.12 (1.22)	0.04	0.571
H34. Used a water pump or siphon	2.49 (1.17)	2.43 (1.14)	0.06	0.394
H23. Prepared food over a campfire, open fire or stove burner	3.11 (1.03)	3.03 (1.05)	0.08	0.253
H45. Sent or received an SMS (text message on mobile phone)	2.16 (1.17)	2.08 (1.16)	0.08	0.300
H29. Been to a hospital as a patient	2.69 (1.04)	2.6 (1.06)	0.08	0.208
H9. Visited a science centre or science museum	2.34 (1.15)	2.23 (1.17)	0.11	0.137
H37. Used a windmill, watermill, waterwheel, etc	2.06 (1.12)	1.93 (1.07)	0.12	0.080
H42. Measured the temperature with a thermometer	2.35 (1.23)	2.22 (1.22)	0.13	0.099
H54. Cooked a meal	3.55 (0.74)	3.37 (0.87)	0.18	**0.001**
H20. Knitted, weaved, etc	2.45 (1.12)	2.15 (1.07)	0.30	**0.000**
H53. Baked bread, pastry, cake, etc	2.65 (1.16)	2.28 (1.19)	0.37	**0.000**