Relevance of science education in Zimbabwe from the perspective of secondary school children

-the voice of the learner about science and technology in a developing country

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

December 2011

Dedication

To my late wife Gamuchirai Mavhunga

Declaration

I declare that

Relevance of science education in Zimbabwe from the perspective of secondary school children -*the voice of the learner about science and technology in a developing country*

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.

Francis Zvidzai Mavhunga November 2011

Signed..

Acknowledgements

I acknowledge my supervisors Prof Cyril Julie, Prof Svein Sjøberg and Prof Oyvind Mikalsen for encouraging me with their forthright and frank advice.

I am grateful for the Norwegian funding under NUFU which enabled the GRASSMATE Project (Graduate studies in Science Mathematics and Technology Education) to exist.

My family has been extremely supportive in circumstances where I was giving up due to serious illness and loss of life. With support from my late wife, sons and daughters it made more sense to keep on working against all odds.

Above all my gratitude is to God who is with me through all the hard times and the good times.

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Abstract

In all countries, regardless of culture and level of development, science and technology (S&T) are seen as key areas for further material development and welfare. A certain proportion of the population needs to develop S&T-related skills and competences at a high level. But also for the majority, who will not enter such careers, S&T are key subjects to master the challenges in everyday life and for full participation in democracy. In our efforts to make S&T attractive as careers and as a key subject for mastering challenges in everyday life, we need to know more about the interests, concerns and values of the learners.

The study of Zimbabwean learners sought to find what students like to learn in science, their interest in science lessons, use of science principles in everyday life and what attitudes they have about the environment. Learners' attitudes to S&T were also measured by an open ended question that sought their ideas on what they would like to research on if they were scientists.

The empirical basis for this thesis is data collected with the ROSE instrument, developed by a team of international scholars in S&T education. Data used in this thesis is from twenty one secondary schools in Zimbabwe (N=734) targeting sixteen year old learners. Comparisons are made with twenty eight other countries.

Factor analysis and descriptive statistics has been used to make comparisons of Zimbabwean and international trends.

The Zimbabwean sample generally showed a mismatch between their expectations and realities of the science education curriculum. Results suggested that Science education was largely irrelevant to their needs and interests. Many out-of-class experiences were not explored in science classes. However, the sensitivity of learners to significant issues around their lives, such as AIDS and other diseases showed in their wish to research to cure those infected.

The newly found voice of the learners will provide new insights on how to improve science education in Zimbabwe in such a way that it is able to meet the hopes, aspirations and the perceived interests, needs and priorities of the learners. Rapid developments in mundane applications of science and technology require that the curriculum negotiates a level that empowers learners to cope with a technologically driven world.

For the development of capabilities to understand and use science and technology, either in daily life or study at higher levels the science education debate must periodically consider needs, views and concerns of the learners themselves among other stakeholders.

Key words

Relevance; interests; capabilities learner's voice stakeholder

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 Introduction

The Relevance of Science Education (ROSE) is an international explorative study focusing on the views of learners about Science Education and Science and Technology (S &T) across different cultures and different levels of economic development. The average age of participating learners is 15 years for most countries although variations were noted in other countries for different reasons. Around the age of 15, learners in most countries are at a stage where interests and expectations of their future lives are very diverse and are in a formative phase. Beyond that age decisions about future careers become increasingly focused, subject specialisations also emerge in the school curriculum and the choices made will significantly influence future lives. At the same time it is a fairly mature age to be able to make and articulate personal interests.

This study is about the (ROSE) project in Zimbabwe, occasionally comparing with other participating countries. The ROSE project is based on the realisation that life in every country is influenced by science and technology. The selection of relevant curriculum matter and methods is not simply a matter of transplanting what is in use elsewhere. With increasing globalisation and modernisation, science education is persuaded to change accordingly to remain useful in changing realities. Education as a whole is becoming less defined by national interests and local institutional traditions. With technological advances in information traffic, physical movement of goods and services between countries, national education systems have to accommodate exchange of ideas and cultural artefacts at a faster rate than ever before. Science education now has a responsibility to prepare learners for a much more dynamic world where the diversity of experiences can only be prepared for through well nurtured attitudes and worldviews. While new technologies provide new opportunities, virtual realities and do away with limitations of time and space, the educator of science has a special need to be informed about the attitudes and emotions of the learners and other stakeholders in the science education enterprise.

In Africa, the pressures of globalisation and internationalisation define larger change jumps than many parts of the world (Ouattarra 1997, Fisher 2001). This makes the ROSE project particularly important to provide a basis for understanding the role of science education in this change process. Its sensitivity to cultural diversity and personal motivation of the learner is critical for informing processes of policy development and debate on science and technology issues. Therefore people form attitudes about science and technology and its education basing on their lived experiences with science, aspirations in life and concerns about the global environment (Schreiner & Sjøberg, 2004).

It is also noted that the access to science education and the curriculum that can imbue learners with correct sense of democratic engagement are coloured by the gender bias, poverty and political process. In Zimbabwe, there is a continuing effort to improve access of science and technical education to girls (Shumba, 1997) through UNESCO and the Ministry of Education. Youths also get an orientation to politically toned perspectives of patriotism and engagements in science and technology as vehicles of personal and community development (Tshabangu, 2006).

This chapter will explore the importance of listening to the views of learner and what exactly are we going to listen to. The ROSE Questionnaire (Sjoberg and Schreiner, 2004) allows learners to say things that can be used in thinking and putting together a curriculum for learners, taking into consideration their attitudes, interests and ambitions. Five major questions make the basis of carrying out this study and this thesis attempts to answer them.

1.2 The affective dimension in Science Education

The affective domain is made up of abstract constructs such as values, attitudes, interests, opinions and beliefs, which influence human behaviour. Their abstract nature makes them difficult to measure and define objectively. That a relationship exists between the affect and behaviour is well established in psychology (Sinclair, 1985; Krathwohl, 2002). Major limitations in affective domain research hinge around this abstract nature which makes it difficult to have unified definitions of terms and diffuse assessment techniques. Teachers find affective objectives to be more difficult to teach and assess (Alsop &Watts, 2003). Alsop and Watts (2003) underscored that in essence, ‘affect surrounds cognition’ and ‘emotions as the guidelines for our lives’ (Oately & Jenkin, 1996). Despite this central nature of the affective domain, research in cognitive and psychomotor domains has proceeded more extensively over the years. In the 1990s, research into the influence of attitudes in science education largely declined with many studies producing results that gave little change in classroom practice in science teaching and gave little direction for further research in the subject. A more fundamental development was a paradigm shift from behavioural to cognitive orientations (Koballa *et al*, 1994) where beliefs are thought to influence cognition more.

Questions remain in science education about clarifying the affective-cognition relationship for teachers to use successfully in classroom practice. Science educators need to know the affective structures that drive students to want to learn one thing and not another. A world-wide trend of declining interest in scientific careers is bringing a renewed impetus to research in the affective domain. The ROSE study is one such study that will help explore the views of learners to further the understanding of affective issues in science education.

Attitudes and interest in science are stressed in the curriculum as one of the aims of high school science. This is a most important aspect of the science education enterprise underpinning the motivation of learners towards science. There is a difference between having a long lasting motivation to study science in and out of school and having a 'scientific attitude' of being sceptical and suspending judgement until informed by empirical evidence. Several characteristics pass for a scientific attitude: observation, scepticism and testing the accuracy and authenticity of information, rationality, honesty, persistent hard work, intellect and others. Interest in science may depend on one having a good teacher who makes the subject interesting, a career goal that one has or rewards of money and fame that comes with a career.

1.3 Aims of the research

This study explores views and attitudes of Zimbabwean secondary school learners to school science, the environment and science and technology (S&T) in everyday life. What science is relevant for modern learners in Zimbabwe? What is the voice of the learner concerning science education discourse? Learners are not usually able to contribute to decisions about science education, the content selection and the methods used in learning it.

Science education generally guides youths through systematic thought and practice, to use existing scientific knowledge to create new knowledge and negotiate meaning from their experiences (Sjøberg, 2003; Osborne and Hennessy, 2003). Responses to the ROSE questionnaire will be used to reflect on arguments for purposes of science education (Osborne and Hennessy, 2003). The expected benefits of science education can be examined from the perspectives of learners.

Generally learners get disillusioned when the perceived benefits of science do not materialize, such as raising the standard of living whereas in everyday life science education does not result in economic empowerment. The study will examine how much trust learners put in science education both as a lived school experience and as empowerment for economic productivity after school.

School science opens learners' minds to issues of special importance. Osborne (2000) notices the irrelevance of British school science when it purports to instil beliefs in a regulated scientific method, yet it is widely accepted that even scientists and their organizations do not come up with very precise definitions. The UNESCO National Report of the Republic of Zimbabwe on Developments in Education (2001) [hereinafter referred to as the UNESCO report (2001)] clearly expresses the dissatisfaction of Zimbabwean learners with the curriculum as many school leavers are not able to get or create employment. Industrialists also complain about the poor standards of school leavers when they join the labour force. To this end it shows that large investments are needed to develop scientific skills that learners are expected to have by the time they finish the compulsory part of secondary education. The aims, content and process of science education as practiced in Zimbabwe needs to serve a developmental relevance to the lives of Zimbabweans.

To be effective in the human development processes, science and science education programmes have to be relevant to the local and international circumstances of the people. Development requires interdisciplinary innovations (Arocena and Stutz, 2005) in which science education 'equips learners with a system of analysis to master diverse forms of knowledge for progressive global welfare.' If science education must contribute to human development, the one place to look for indicators of progress or its potential for progress is in the attitudes of the people to science, technology and education. The research studies how Zimbabwean secondary school learners view science education, their interests in science, expectations of their future and their understanding of science and technology, in transforming their circumstances. Attitudes of learners can be a useful indicator of the extent to which they find science education relevant to their goals in life. To enable exploration of the attitudes of Zimbabwean learners, five different questions are analysed in the research.

1.3.1 Question 1: What are the interests of secondary school learners in science?

This question seeks to simply explore and describe the interests of the sampled learners in Zimbabwe and other international participants in the study. Indications about what they want to learn are regarded in (this study) to be influenced by the needs, values and aspirations of the learners. The underlying constructs accessed through factor analysis may explain the way they respond to questionnaire items. The most important benefit of finding the interests of the learners is that it gives a voice to such a group and allows them to *'participate'* in the debate of their curricula. Stakeholders in science and all other subjects rarely include the students in planning educational programs. Progressive pedagogic approaches encourage learner-centred interaction in the learning environment. Eliciting the ideas of the learners about what they want to learn is a necessary process which ideally must be integral to the curriculum design and development processes.

1.3.2 Question 2: What attitudes do learners hold about science lessons?

Participation in the learning process changes existing attitudes about science and moulds new ones. Whatever learners call 'science experiences' are regarded in this study to be those things they learn when an activity results in new knowledge in science. This may be influenced by the ability of their teacher, their environment and special circumstances. However, since these vary by country and geographical region, this study was not focusing on the nature of the process but the resultant attitudes. Learners also come into school with pre-conceptions learnt from home, life experiences and significant others. Teachers need to use preconceptions as a basis for learning new information and modifying the preconceptions where they are found to be mistaken (Sherman and Kurshan, 2004). By studying the resulting attitudes of learners it is possible to engage in reflective issues such as:

-Are learners developing better sensibilities from science education, based on the things they say they prefer and aspire to?

-Is science education being relevant to the needs and experiences of the learners?

1.3.3 Question 3: How out-of-school experiences match learners' opinions of S&T?

Learners' opinions about the relationship between S&T and their out-of-school experiences will be explored to establish how everyday experience matches their ideas about transforming their welfare through scientific knowledge. Science as a way of creating knowledge exists in all modern cultures. However, common usage of the term science refers to high school science and technology as the product of scientific research and development. S&T in the Zimbabwean society is a complex combination of traditional African technology and practices alongside modern products.

Learners coming from different economic strata have different levels of contact with products of S&T. A middle class home would have electricity, running water, at least one car and perhaps not more than two people per bedroom. Lower levels such as in rural areas and farming communities are likely not to have electricity and at best may draw drinking water from mechanised wells. Otherwise the majority of people (75% of the population is rural) have no electricity, no access to a phone or running water and sanitation. The increase in mobile phone access has greatly improved communications but still leaves a significant number without network services.

Out-of-school experiences give a good measure of how the learners are likely to be getting practical stimulation to think and act on the principles of science learned in school. At the same time it must be noted also that the forms in which many products of S&T are available to users are not likely to teach the users of the scientific principles involved. A learner, who has access to the internet, may know very little about the basic physics of signal generation and transmission. However, the experience is likely to enable such a learner to understand it better than one who has to imagine what internet is. It is also quite common for learners to become more aware of some technological innovations because of contact with them. Using a mobile phone is quite common to urban societies and urban learners are more likely to experience the positive use of electromagnetic radiation waves in the mobile phone.

In the light of experience as a contributing factor to capability building, it is noticed that learners in the new millennium generally have higher technical skills and confidence in using computers for basic functions such as processing music, emails, browsing the internet and communication. At the same time, the older generation technologies such as use of tools to do simple repairs, construction of items from raw materials is getting less and less popular. With changing circumstances, generally people have less and less to do with animals that there are now more Zimbabwean people who do not have experience with plants and animals in the traditional rural homes. Technical development has reduced the need to keep dairy cows, sheep and goats; more efficient farming replaces the need for every household to farm. Out-of-school experiences are the arena of practical lessons that nurture creativity and initiative that enables people to make choices in life.

1.3.4 Question 4: How is science education important to learners' for future careers

The questionnaire elicits thoughts of life after school from the learners. What do they consider as important from school science? From a descriptive analysis of their interests in science and expectations of their future, one could understand how much they are empowered to reach their potential in developing their well-being and that of their country. Empowerment is about giving a person the confidence and expertise to exert themselves so as to realise their true potential (Sen, 1990, Early, 2007). As a general rule it can be said that people cannot be developed but rather they develop by applying themselves to their life circumstances to achieve things they value (Sen, 1999).

The future of any person depends in part on their present circumstances. Typically, learners expect to earn good grades that can distinguish them as eligible for employment. So what happens to the majority that do not make the grades? For learners who grow up in harsh economic circumstances, many of their expectations are probably never realised.

1.3.5 Question 5: What are the research aspirations of learners?

One important indicator of the attitudinal maturity of learners is to let them imagine what they would want to research on if they were grown up scientists. At the age of 16 years, most people are reasonably capable of logical thinking. Knowledge of the needs of their societies and the fact that many solutions have come from science is quite well established by age 16. The ROSE study invites learners to think in this way, without guiding them what they must think about, the study seeks to draw on the existing levels of motivation, attitudes, and expectations of science and needs of different societies. Putting the respondents into an assumed role and responsibility of a thinker, given all the opportunities it can elicit the essential aspirations of a whole nation. Study of aspirations has yielded important information in other researches such as by Abela, (2007) in East Timor. Abela surveyed 10 000 children (ages 9-17) in 17 East Asian countries and profiled varying proportions of aspirations which reflected the cultural and environmental effect on choices made by adolescents. In other words, learners are again accorded a platform where they can express their aspirations and such information is vital for educational debate.

1.4 Why listen to learners in the first place?

The value of listening to the pupils is very optimistically outlined by Cullingford (1991)

> *Children reveal that they have the articulateness and honesty to analyse what they experience. They show consistent judgement and evidence for what they are saying. Their views deserve to be taken into account because they know better than anyone else which teaching and learning styles are successful, which techniques of learning bring the best out of them … listening to children makes us consider some of the habits we have taken for granted.*

The value of the learner’s voice is critical to the teacher to design educational experiences that make school science meaningful and for the child to enjoy learning. Establishing a relationship between school and daily life is a powerful pedagogical tool which can only be efficiently deployed when the teacher has some idea of what the learners find meaningful. Children learn best when they are motivated. This is by no means implying that curricula should be written by learners, but the inclusion of their views makes for a balanced menu of activities.

Decisions to drop out of school often result from circumstances either within or beyond the control of learners. Financial constraints, armed conflict, disease and natural disasters are some reasons why learners stop going to school. However, other reasons such as indiscipline, substance abuse and peer influence can be controlled with the involvement of the learner in deciding what is good for them. The views of learners can be incorporated into the learning by selecting experiences from their lives which bring meaning and purpose to lessons. The Science and Scientists study (Sjøberg, 2000) is one example of an exploration into the views and aspirations of learners which provided a means of understanding how learners think about science. The value of exploring learners' attitudes is in helping teachers to create learning environments and contexts which can help learners formulate concepts in their minds.

Good policy making practices increasingly include all stakeholders in the formulation process. The value of a shared vision is that it ensures that every player in a system is aware of his / her role. Science and technology products that society consumes are only relevant when they suit the needs of the users. For the average man in the street, science is not a field of study that one can easily influence. However, education empowers people or the consumers of the products of science and technology to drive scientific enterprise rather than be driven by it. School science is one place where learners experience democratic participation by contributing to what they learn. There is a growing body of literature on learner participation in the design of the curriculum is secondary and higher education (Gross, 1997; Maier, Allert and Richter, 2006). Arguments can be made that learners are not knowledgeable enough in the subject to contribute meaningfully to what they must learn. The reflective analysis made by Gross (1997) regards a wider range of variables such as learner attitudes, interests, contexts and experiences as necessary components of the curriculum. The participation of learners in the design of the curriculum does not depend on content mastery; there is more to curriculum design than simply choosing topics.

Structure of the education system

The Zimbabwean education system follows the 7-4-2 year progression from primary school (age six) to the end of high school (pre-university). English is the medium of instruction for all subjects except the vernacular. Form Four and Form Six levels were examined by several British examination boards such as University of Cambridge Local Examinations Syndicate (UCLES) and London Examinations. Up to 1985, there existed a second progression of 7-5years, which however would not lead to university entrance. The 7-5 progression, leading to the Zimbabwe National Certificate of Education was discontinued because the high school graduates then could not compete favourably for employment with international General Certificate of Education from UCLES.

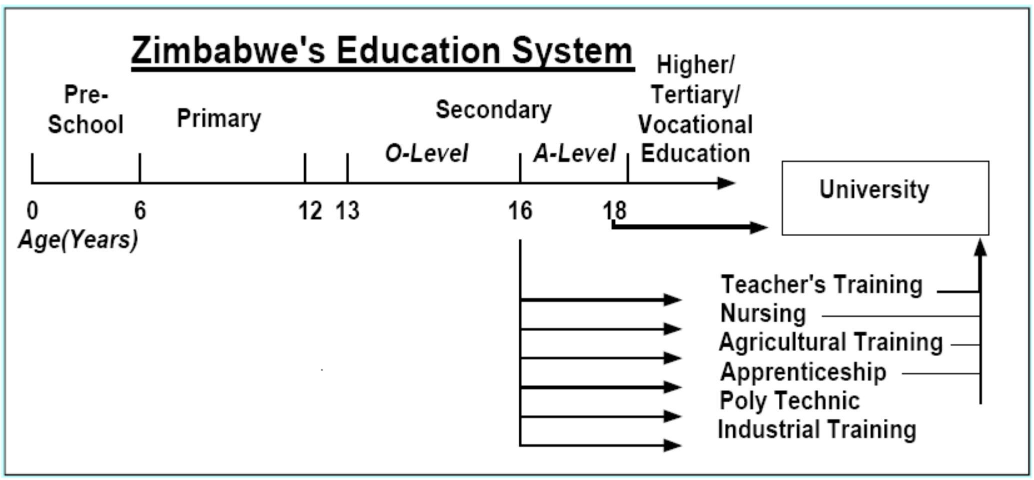


Figure 1-1 Summary of the Zimbabwean education system (Source: UNESCO Report July 2001)

Basic education

Basic education is made up of Early Childhood and Care (ECEC) for learners up to six years old and seven year Primary Education for learners from six to twelve years of age. Basic education is compulsory and there is unimpeded progression up to a terminal examination in Grade 7 the last year of basic education. The compulsory nature of basic education is the government approach to achieving the aims and objectives of Education for All in line with its prioritisation of education and the worldwide drive for universal basic education.

Secondary education

From the age of 13 to 16, there is a four year compulsory secondary school education and it is not free. Progression used to be in two steps, namely Junior Certificate of Secondary Education (JC) after two years of secondary education and Ordinary Level (General

Certificate of Education, GCE) at the end of four years of secondary school education. Though not impeding progression, the Junior Certificate was in many schools a segregation level after which those with strong performance in the sciences were channelled into Physics, Chemistry and Physical Science classes. Less successful JC graduates were channelled into commercial subjects and General or Integrated Science. The segregation at Ordinary level had immediate implications for the kind of advanced studies and career one could take after school. Performance at this early stage of secondary school had implications on all future career prospects. Career choice and interests were largely controlled by many external regulations.

1.5 Types of schools

Different types of school reflect different economic endowment. The political and economic history of the country is etched in the infrastructure development of the different areas of the country. The independence period from 1980 has seen very significant movement in the quantitative development of education. Quality of education however has not been uniform in the different areas, and the imbalances of provision of education coming from the past political dispensations and scarcity of resources still influences the level of development in the different provinces.

1.5.1 Rural day schools

Rural schools are constructed and funded through Rural Development Councils and religious missions. In the pre-independence period, the missionaries set up most of the schools in the rural areas. Nhundu (1992) and Riddle (1980) describe government's deliberate retardation of rural school development by starving the schools of financial support. Council schools were poorly funded and depended on 'building funds' contributed by parents besides the school fees which were a severe barrier to the largely poor communities. After 1980, the legacy of impoverishment did not change significantly (Drinkwater, 1989). While the Zimbabwe government established more schools, the countryside remained unattractive to trained and experienced teachers. Without electricity, running water, telecommunications (in some places even radio and TV transmission could not be received) and far away from the desired comforts of towns, such schools did not have adequate accommodation for teachers. Long distances, unreliable transport, poor health and educational facilities made it unfavourable for young teachers coming from urban or better developed areas to go the remote areas where they would be expected to raise their own families working there (Nyakutse and Biswalo, 2008).

Facilities such as laboratories, equipment and books were very limited and often poorly kept. Lack of space forced teachers to use science store rooms as offices as well. In some schools the skills of setting up and running a science lab were not found because many teachers were not trained. Learners attending rural day schools had limited access to information. Rural areas are traditionally far away from several elements of technological development (Bennel and Ncube, 2004). With expanding mobile networks, it is increasingly becoming possible to have communication in the rural areas, though not all areas are covered.

1.5.2 Rural Government Boarding schools

These schools were built in the post-independence era by the government in rural areas. Technically they were supposed to serve the communities in which they are situated. One such school, Chindunduma High School, situated in the north eastern district of Mt Darwin largely draws its enrolment from all over the country, especially the major towns. Parents in the neighbourhood of the school do not afford the high fees required at boarding schools. Only a limited number of day school vacancies are offered. So even if these boarding schools are in the rural areas and are well staffed and much better equipped, they are really not a reflection of true rural life. The students here are urban learners who only come during the school term. While the government tries to insist that no child shall be denied education because of school fees, the reality about boarding schools is that boarders must be fed and housed by the school, fees have to be paid. Inflation has been increasing rapidly since the year 2000 and parents from many areas increasingly find it difficult to send children to boarding schools.

1.5.3 Urban Day schools

At independence the government increased the number of urban schools, building the same general architectural plan of school in many urban residential areas. Towns were supporting extremely large populations at the end of the war as many people had fled the war in the countryside. The demand for schools in town was high and the central government teamed with local authorities to build schools. Generally these schools received good levels of capitalisation and they were capable to offer a wide range of subjects. Being in towns they were also able to attract well trained and experienced teachers. The majority of schools offering Advanced level are found in towns, another factor which drives rural to urban migration, in search of education.

Learners in urban schools have more access to higher standards of living, electricity, water, transport and communication, access to information, equipment and the media. Their exposure to modern science and technology is understandably much higher than their rural learners and hence their socialisation exposes them to wider scope of aspirations. Urban schools were all day schools and offered evening classes to workers and drop outs who desired to have extra tuition or help in completing high school.

1.5.4 Private schools

These are high fee paying schools usually only accessible to a very small proportion of the population. Clients are usually drawn from the upper economic levels of society, business families, diplomats, academics and politicians. In this category are also some schools that were historically 'white only' schools. Parents in the schools are generally well employed and through their boards of governors they raise payments for facilities which government generally cannot support. Government has very little control over private schools which determine and pay their own salaries and run their budgets on very high school fees. A short lived government in 1979 (which named the country, Zimbabwe-Rhodesia and led by Bishop Abel Muzorewa) enacted a policy (Education Act 1979) which introduced "community schools". Communities were given the right to purchase schools in their area to become their private property (Mudariki, 1981). White communities used this opportunity to buy schools for as low as Z$40 000 in some cases and could make them exclusively white, charging very high fees beyond the reach of many blacks.

1.5.5 Farm schools

The main economic pillar of Zimbabwe is agriculture. Vast farms and estates employ thousands of people. Migrant labourers were drawn from Zambia, Malawi and Mozambique during the pre-independence era. These people lived and worked on farms in Rhodesia for several generations and established farm labour communities that had no other home except the farms. Steeped in traditions that were extracted from neighbouring countries, the migrant communities were in many ways stateless people who were not fully integrated into Zimbabwean society but had largely lost contact with their families in their original countries. They became a generational labour reserve for the commercial farmers (Jena, 2011). Prevailing economic conditions also drove learners into farm labour in order to gather enough money for a living. A good number did manage to break away from the farming communities and join the mainstream society through marriage and education. Successive farm dwelling generations were not covered by many of the government educational programmes. Withholding educational opportunities to such communities worked well to keep them around the farms earning just enough to keep them as a vibrant and loyal labour force. Small primary schools were started at farms, usually going up to Grade 3 or Grade 5.

1.6.6 After independence in 1980, many of these farm communities did not get as many schools as the rest of the rural and urban population in the expansion of education. This apparent negligence is evident even in the Annual reports of the Secretary of Education, which did not show any significant statistics of direct support for farm schools. Farm owners in several places then managed to get their schools registered with the Ministry of Education so that they could get support of teacher's salaries from government and hence drew the government to take part in the education of farm communities. Ironically the commercial farms were the mainstay of the Zimbabwean economy yet the workers were among the poorest people in the country with little or no education, no land rights and inextricably tied to providing labour for very low wages. (Countries and their cultures: Zimbabwe)

1.6.7 Mission boarding schools

Religious missions such as Catholic, Anglican, Methodist and others established schools that are usually better resourced than government schools. The fees at mission schools are generally lower than private schools but have traditionally produced the highest pass rates in Ordinary and Advanced level examinations. School leavers from mission schools have generally been successful in life, with a high percentage passing well enough to progress to tertiary education and taking up graduate professions. The number of mission schools has remained fairly static ever since independence when the government rolled out its education expansion plan. Teachers' salaries in these schools are paid by government and generally they have good accommodation, electricity, running water, communication facilities and can attract well trained and experienced teachers. Most mission schools were established in the Southern Rhodesia period as educational oases for African learners. With time they have built traditions of academic excellence, and have several influential alumni in industry, government and abroad. At times the alumni have supported their former schools generously though this is isolated and cannot really be regarded as characteristic of all mission schools.

1.6 Conclusion

Zimbabwean youths, like most African people are caught in a dynamic context in which economic systems and the politics of their country is dictating everything in the fibre of their societies. The natural resources of the country and the prevailing traditions prioritise education and productivity. For youths growing up and receiving an education in the country, the economic and political environments cannot be ignored in making any choices about future education and life. While the study focuses on eliciting the voice of the learner, it is imperative to keep in mind the issues that threaten life in Zimbabwe.

Very significant pressures result from issues that are completely beyond the help of a child; HIV/AIDS, politics, economic decline, climate change are all at play at the same time. The idea is not to imagine a world without these problems, but to accept the reality that these are the problems besetting learners in Zimbabwe. Do the learners in our schools find science education relevant to their needs, now and in their future?

Chapter 2
Theoretical framework: Capabilities approach

2.1 Introduction

In this chapter, I discuss the relationship between relevant education and the empowerment of learners with skills to develop their lives. It is informed by the seminal work of Amartya Sen, The Capability Approach (CA) (1999). Amartya Sen was awarded the Nobel Prize for Economics Sciences in 1998. For four decades (from 1960s) he studied and published on several issues including welfare economics and social choice theory. As a result of the CA it is deduced that the curriculum, including school science equips learners with skills that they will use to make their lives more desirable and valuable to themselves.

This study analyses the views of secondary school learners on science and technology and the importance they attach to it. One assumption is that every learner has a certain perceived value attached to the studies they take at school. Such value perceptions may be influenced by the hope that through studying they may empower themselves to achieve careers and skills they desire in their lives. The perceived benefits that learners attach to science and technology are informed by lived experiences in their environment, aspirations based on seeing the performance of other people that act as role models or simply initiatives evolving out of a people who acquire appropriate capabilities (Kent & Towse, 1997). These capabilities are what a person brings to contribute to the development of all humanity through his or her local action.

So generally, capabilities are formed out of the opportunities, existing knowledge and skills and motivation to achieve different and better results. At any time, capabilities are dynamic, consisting of inter-connected uses of knowledge; creation, integration and absorption and reconfiguration (Verona and Ravasi, 2003) as summarised in Figure 2.1. The knowledge and skills that get into this cycle are those forms that are available, dominant, useful, achievable and necessary to attain set objectives. It is not possible to make a complete ordering of capabilities needed in life on the basis of science education only. Capabilities result from experiences in all other areas of experience, formal and informal. The relevance of experiences is therefore fundamental to the career direction that an individual is likely to grow. It is imperative that the concept of relevance is explored in relation to the capabilities that one needs to develop. Whether learners achieve their ambitions or not is another issue but the direction of the voice of the learner is what needs to be heard.

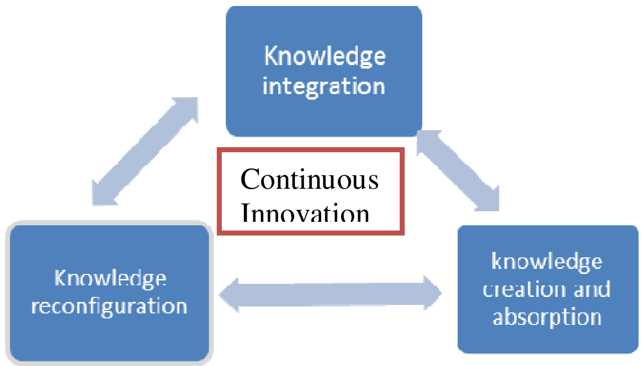


***Figure 2-1** Dynamic capabilities (adapted from Verona and Ravasi, 2003)*

2.2 The capabilities approach.

The seminal work of Armatya Sen, from the 1960s to 1999, called the Capability Approach (CA) has influenced 'disciplines, institutions' (Page, 2005) and policies and practice of UNDP and the World Bank. CA has provided the theoretical framework for the human development paradigm (Robeyns, 2005). Armatya Sen was awarded the Nobel Prize for Economics in 1998 for this work and he summarised it in a book called 'Development as freedom' (1999).

The essence of CA is the "substantive freedom of people to lead the lives they have reason to value and enhance the real choices they have" (Sen, 1999). People are only able to achieve goals to the extent that they have capabilities to apply themselves to those goals. In Sen's perspective, capabilities are the real opportunities (environmental opportunities and individual abilities) that a person has to lead a life he or she values (Gasper 2007). In the progressive advancement of knowledge and skills acquired by a growing individual all energies are constantly aimed at achieving desired states of being. Societies and nations are communities of interdependent humans sharing the same geographical and temporal existence. Education plays a critical agency in equipping a given society with the appropriate capabilities to achieving and maintaining a desired life especially if it is relevant to the needs of the people.

For many centuries, people in different ecological regions of the world have developed knowledge systems that enabled them to cope with their environment and to draw a sustainable livelihood. Survival and good quality life as perceived by the people of any locality depends on the capabilities they have and the opportunities thereby to apply themselves. An example is the San people of the Kalahari Desert. They live in one of the most arid and harsh environments and have some developed capabilities like sustainable utilisation of their natural resources and knowledge of ethno-medicine but do not regard income and individual ownership of land as a necessity in their lives. Such an economy is in stark contrast to property-value driven and market-oriented economics. The two economic systems are just different but people live to old ages in both geographic places and people from either economic system can realise what they call valuable and relevant.

'The Capability Approach is a broad normative framework for the evaluation and assessment of individual well-being and social arrangements...' (Robeyns, 2005) The individual is at the focal point of the CA, but individuals belong to communities. Robeyns, (2003) analysed capabilities and noted that capabilities open the idea of development beyond the simplistic provision of resources or satisfaction of utility purposes:

> *The capabilities approach advocates that … we focus on what people can do and be, instead of exclusively on their mental states (utilitarianism) or on the goods that they have at their disposal (resourcism) (Robeyns, 2003).*

She conveys in this quote, the essence of the overarching framework of the capabilities approach. The focus on what people can do makes it possible to analyse a wide variety of disciplines that govern human welfare, including science education. The capabilities approach brings out the interrelatedness of human welfare with commodities, personal skills and social conditions. Amartya Sen developed the principle of CA in the context of human development and has had significant influence in the Human Development Index. Martha Nussbaum (1993) and other scholars expanded it to apply to other areas of human welfare (Schischka, 2002). Sen makes a core argument that

> *…our evaluations and policies should focus on what people are able to do and be, on the quality of their life, and on removing obstacles in their lives so that they have more freedom to live the kind of life that, upon reflection, they have reason to value* (Sen, 1999).

Capabilities are the alternatives that an individual has at his or her disposal to be able to lead a kind of life they choose (Saito, 2002; Dréze and Sen, 1995). Such capabilities are influenced by public policy, and (moderated) by levels of democratic participation of the public. Human well-being focuses on 'freedom to achieve in general and the capabilities to function in particular' (Sen, 1995). Sen (1995) acknowledges a mutually enhancing relationship between commodities, income and human capabilities (Saito, 2003). Capabilities include the ability to transform the environment, to construct shelter, extract food, clothing, minerals and many other things for livelihood (Ntarangwi, 2004).
In the Capability Approach, 'unfreedoms' are deprivations of freedom and take a wide range of forms such as poverty, malnutrition, disease, poor health care and others, generally taking away from people's opportunity to engage in activities they value and leading to morbidity and premature mortality. The life expectancy in Zimbabwe for instance (39 years male) is lowered by a compromised health delivery system, famine and general economic decline (HDR 2010). As a result of these deprivations, people are not free to develop themselves as they would wish.

Irrelevance of school curricula is a subtle form of deprivation. Resources are spent on educating people in content and skills which are not usable in their circumstances. Such irrelevance takes away the opportunity for learners to exploit necessary capabilities at the right time in their lives. HIV and AIDS, political unrest, poor macro-economic fundamentals obtaining in Zimbabwe in this decade, are significant threats to the adequate provision of science education.

2.3 Education and the Capabilities Approach

In this section the relationship between capabilities and education is explored. Amartya Sen wrote the Capabilities Approach from his perspective in economics rather than education. The implied relationship between capabilities and education is explored by other scholars (Saito, 2003, Robeyns, 2005, Unterhalter, 2005). The relationship of the capabilities approach and education is viewed from a long term perspective on the positive impact on communities.

The ultimate goal of CA is to empower people to achieve well-being. Development is a state of becoming better, more sophisticated, richer and better able to deal with daily problems than before. It transcends individual, community and national levels, the individual being the first focus of CA. An assumption made is that if the individual achieves a state of well-being, it has the effect of multiplying in the community through families.

Three things are found to be central to the development of an individual.
First, there are functionings, which Sen defines as 'the various things a person may value being or doing (Sen, 2005), such as 'nourishment, being happy, avoiding escapable morbidity, having self-respect and taking part in the life of the community' in (Comim, Qizilbash and Alkire, 2008).
Second, there are capabilities which are 'the various combinations of functionings (being and doing) that a person can achieve' (Sen, 1992). They represent a person's real opportunities or freedoms.
Third factor influencing the development of an individual is agency. Sen (1999) defines an agent as 'someone who acts and brings about change'. The essential role of teachers, parents, siblings and the community in influencing development becomes apparent.

Nussbaum (2002) explained education in a four-pillar framework that relate to capabilities.

1. Learning to know or 'Practical Reasoning' develops cognitive skills necessary for acquisition and use of knowledge. This includes critical analysis, interpretation of information, problem solving and decision making.
2. Learning to be (human agency). This focuses on the person and looks inwards at the self, building goals, identity, valuing oneself etc. The person is seen as

   someone who acts and brings about change, and whose achievements can be judged in terms of her/his own values and objectives, whether or not we assess them in terms of some external criteria as well (Sen, 1999 p19)

3. Learning to do: functionings and capabilities. This pillar comprises skills for life, bodily health, bodily integrity and control over one's environment. It is about the action one makes by action or reaction to situations.

4. Learning to live together: This pillar realizes people as having social capital and it emphasizes the essential skills for human social existence: interpersonal skills, empathy, negotiation, assertiveness, refusal, cooperation and communication. Again the individual is the focus of these skills for the good of all humanity.

2.3.1 Human development index

Education is a natural agency (Robeyns, 2005) in the development of human capabilities and this is acknowledged by the literacy component of the human development index (HDI). The HDI is a measure of the development of a nation, developed by the United Nations Development Fund. It was designed using major with inputs from Sen and his colleague Mahbub ul Haq. HDI as used in 2010 now emphasises education, health and living standards. Sen (1999) recognises that the well-being of an individual and hence a society is not only about the material commodities available to people but rather satisfaction with one's achievement of intended goals. Sen quoted in Saito (2003) noted a principal reason why the HDI is important especially for the promotion of education in a developing country;

> *The HDI leads governments to direct their policy efforts toward different ends— providing health and education for all citizens, and supporting a sustainable environment and a sustainable living standard (Saito, 2003).*

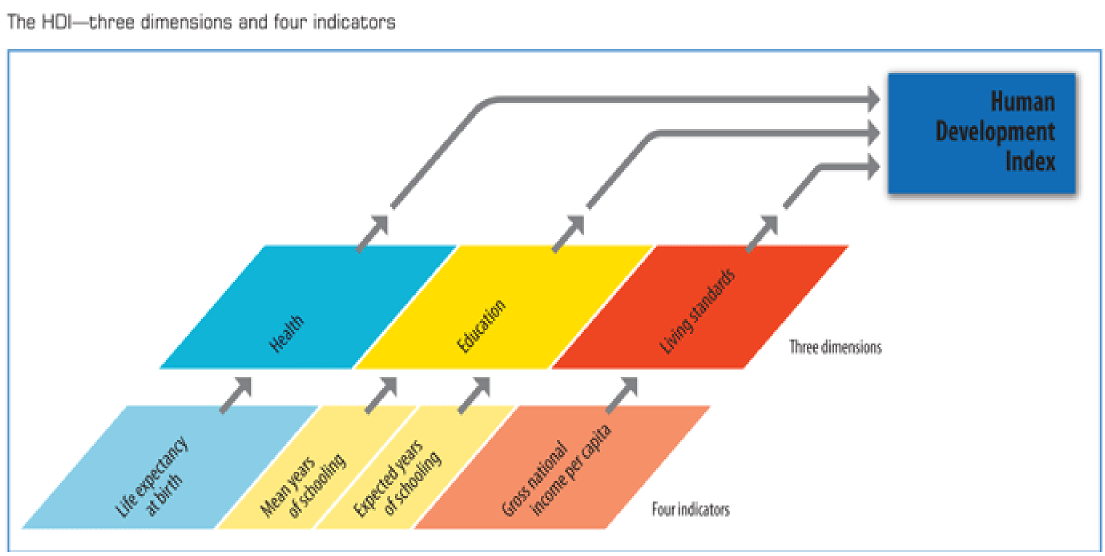


Figure 2-2 The HDI- three dimensions and four indicators (Source: HDI 2010)

As a result, in 1980 Zimbabwe expanded its education (Dorsey, Matshazi and Nyagura 1991) so much that adult literacy on the HDI in 2010 was 91.4% (HDI 2010 Table 13). The Government of Zimbabwe, IMF, World Bank and other development aid organisations use the HDI as a basis for decisions on how to support education. This alone is a direct influence of the CA on the way education and other aspects of human welfare are prioritised.

There are several factors that construct the state of well-being; health, education, income, peace, geographical environment and many others determine to what extent an individual can enjoy the full potential of their capabilities. Education ensures the achievement and sustainability of the constituent factors of well-being. It is a concept of adequacy and contentment deriving from an individual's level of interdependence with the ecological, social and economic diversity in his/her life space. Development therefore, is dependent on the level of well-being; the extent to which individuals can pursue their valued goals, Radjah, Hoffmann and Bakshi (2003) emphasise that the critical relationships and focus of education

> *… must be geared towards enhancing capabilities and enlarging choices and developing agency by building different dimensions of well-being (Radjah, Hoffman and Bakshi, 2003).*

Income is a critical component of the factors that contribute to well-being. Human well-being and science education have an organic relationship in that scientific knowledge opens many more life changing practical opportunities to individuals than basic literacy (measured by years at school).

2.3.2 Disease prevention and management

The realisation of full potential of human capabilities depends on how well children are raised. Empowering learners with capabilities to prevent disease could have saved the people from many deaths. Chronic epidemics of cholera, dysentery and malaria are largely preventable by basic hygiene and sanitation. Many programs costing large sums of money are in place to educate people how to prevent diseases. Education in personal and community hygiene is an example of a capability which can transform lives of a whole nation, change some cultural practices and establish acceptable welfare.

Biology, Human and Social Biology, Food and Nutrition and Agriculture are some science subjects that directly empower learners with skills that can be used in their daily lives. Learners may even fail the level (Ordinary or Advanced) but the skills which they develop by doing the subjects becomes an integral part of their capabilities.

An example can be made of the manner in which science education develops capabilities in health. Epidemiology of malaria shows the extent of devastation this disease has caused in Africa. Behaviour modification is the most effective prevention and learners already begin to change attitudes and behaviours the moment they learn about it. The capabilities they have developed here are knowledge, what they can do (behaviour), and how their knowledge and behaviour impacts other members of society. Knowledge is about the realisation of dangers of the diseases and the need to do something as a community. It also includes the attitude changes and taking control of the environment in order to achieve disease control. Actions that follow to achieve the goal of disease control are varied; trimming grass, clearing stagnant water, spraying chemicals, correct use of mosquito nets and proper use of pharmaceuticals to prevent drug resistance. It does not matter if the examiner sets a question on malaria or not, the more useful result is that this knowledge has become a newfound capability for the learners and they will use it throughout their lives. The quote from Oliver Wendell Holmes (1858) is appropriate here: "A mind that is stretched by a new experience can never go back to its old dimensions."

2.3.3 Capacity for science and technology

Technology is about expanding human capabilities. Many governments, academics and organisations generally endorse the central role of science education in building people's capacity to be functional in 'a world driven by science and technology' ((Sjøberg, 2003, World Conference on Science 1999, ISSEP (2010). This is because history has shown that economically strong countries spend a lot of money and time on developing knowledge, research, innovation and manufacturing and trade. Zimbabwe manufactures very little of the technology that drives its industry, information technology, transport and other aspects of the economy. As far as technology creation is concerned, Zimbabwe (and Africa as a whole) is in a position of 'arriving without travelling' (The Beatles, The Inner light 1969). Africans get to use modern technology but their economies have not travelled the development process that resulted in the technology. Most technology is imported from Europe, America or Asia.

That inability to develop science and technology limits the human capabilities available to the nation.

Social life is also pervaded by so much technology that the man in the street now needs some scientific literacy to function effectively. ATMs, mobile phones, textiles, food, medicines and a host of ordinary daily routines now require some technological literacy of some sort. Even though the technology usually has very user friendly interfaces, it is rapidly evolving, thus demanding constant learning. A good example is the Microsoft Office Word. MSWord 2007 version was working on computers quite well, but just when one was getting to master it fully, Office 2010 came. The capability to learn and consume emergent technology is crucial especially for the youth who need this skill to maximise their productivity in the modern world.

History of science has shown that scientific thought is one important factor that can account for the industrial and hence economic development of Europe ahead of the rest of the world

(Adas 1989). Otherwise before man learnt to apply systematic reasoning to practical ends, Europe was once as undeveloped as Africa. Science and technology provided Europe with a capability to discover more, develop new materials and revolutionised mining, transport, medicine, textiles, trade and most aspects of life.

For as long as Zimbabwe does not join the knowledge industry, it will remain poor. Limited capabilities makes it unable to deal with preventable challenges such as cholera, famine, poor health delivery, lack of infrastructure and reliance on exporting cheap raw materials.

2.3.4 Feminine autonomy

For many decades, women and girls have performed the role of care-givers to families, spouses, the elderly and the sick. Cultural constructs like *hunhu* or *Ubuntu* have arguably sustained a subservient stature for women. It is accepted in Zimbabwean traditions that girls do household chores and other caregiving activities while boys are ostensibly learning male jobs or probably playing. As a result, for many generations, the male child enjoyed preferential opportunities like education. This maintained a low literacy for women, inability to have income, little or no control over their fertility and relegated to live and work in the rural farms while men lived and worked in towns. Females in Zimbabwe are therefore coming from a background of relative disadvantage and no autonomy. In many cases women have even accepted themselves as being lower than men.

In Zimbabwe, girls and boys now have equal opportunities to go to school. Through education, women are better able to make decisions about how many children they bear, feeding them and protecting them from disease. Caregiving involves making the right decisions about nutrition, food preparation and storage, hygiene and reaction to disease. The sum-total of this knowledge is achieving well-being for the community and nation.

2.3.5 Technological capabilities and social change

Mobile phones, social networks like Twitter and Facebook have become a common communication tool for people round the globe. These are very recent developments in the applications of the cyber-technology to social issues. Significant use of Facebook and Twitter for political campaigning was first done by the Obama campaign team in 2009 (along with other strategies). The social network targeted his campaign to young voters in centres like universities, colleges and high schools. Obama went on to win the American presidency. Information technology was found to be immensely useful in spreading information to society. Public riots have been coordinated using social networks in China

(2009), Iran (2009), Mozambique (September 2010), Tunisia (January 2011) and Egypt (January 2011). Governments have been known to disable internet and mobile phones during civil unrest to dismantle information flow.

Disaster situations such as in Haiti in 2010 relied very much on text messages sent from mobile phones. Kenya mobile phone operators now use in for money transfer, a 2007 Vodafone facility known as M-Pesa. This was first used in the Philippines in 2005 and has become a standard in Malaysia and several other Asian countries. Rural communities (totalling an estimated 80% of the population) now have access to banking facilities through mobile technology. Access to banking facilities, no matter how limited, has transformed livelihoods in the concerned countries and it is a positive development towards freeing the people from incapacity. Science education is pressured by such developments to incorporate the appropriate technology content in the school curriculum in order to serve the requisite needs of the people and the technology. When people understand a technology, they are better able to make a positive difference in their lives.

2.3.6 Quality citizenship

Education plays a major role in expanding the capabilities and opportunities available to learners. The possibilities laid open by offering science education are not only in job prospects but also for wider purposes of achieving quality citizenship (Riquarts, 1987). Relevant science education considers children's interests in content and methodology of the learning experience, thereby increasing the attitudinal matching of school science to their interests. This is not to suggest that the curriculum should be based only on children's interests, nor should society rely entirely on technology (Meserve, 1998), but that of all the stakeholders, the learner's point of view is the least considered. Science education aims at more than producing professionals in science. Its purpose of utilitarian, democratic, cultural and economic functionality addresses the quality of well-being for all individuals in every walk of life (Osborne & Hennessy, 2003).

Learners who pursue what they *want* to learn exercise their democratic right to choose their career. The provision of facilities to choose from is therefore a means of enabling democratic participation by an individual in their communities. Saito (2003) makes a very powerful analysis of the options available to learners. Education gives the learner autonomy, that ability to make choices, but the quality of the choices are limited by a prescriptive system which declares what must be learnt and how it must be learnt in a 'top-down' approach. Responsible autonomy is nurtured in children (future adults) when they make choices that can be pursued in what and how they learn. Schreiner and Sjøberg (2004) outline the primacy of the affective dimension in the education of children. Consideration of the appropriateness or relevance of the education to the needs of the learners and their communities is a necessary basis for unlimited capability building in educational systems.

2.3.7 Science and technology education and African development

At the 1999 World Conference on Science (WCS), UNESCO, The International Council for Science, 155 governments (including African countries) and 120 non-governmental organisations sought, according to Matsuura (2002),

> *..a new relationship between science and society built on mutual respect and mutual assistance. In a rapidly changing world where knowledge from all fields of science is urgently needed to address pressing human needs and aspirations in a responsible manner that respects ethical values and the planet we rely upon for survival.*

In this way a social contract was negotiated for science, defining the efforts that were needed to respond to social expectations and challenges of development. Central issues identified were such as

> *The need to improve, strengthen and diversify science education, formal and non-formal, at all levels and for all sectors, and to integrate science into the general culture, emphasizing its contribution to the formation of open and critical thinking as well as to the improvement of people's ability to meet the challenges of modern society. (…) Any discriminatory barrier operating against equitable participation in science must be removed, and positive efforts are needed to fully integrate women into the sciences...* (World Conference on Science for the 21st Century*,* 1999).

This quote underscores the four pillar framework of education and capabilities proposed by Nussbaum (2002). The conference sought to promote practical reasoning, action, agency and a culture of problem solving. In the original outlay of the CA, Sen left it incomplete in areas such as technology and education, but other scholars (Nusbaum 2002, Robeyns 2005) have since started exploring the application of CA to areas beyond economics.

From a CA perspective, technology is capacity for human action. It is a means to an end; it satisfies its purpose of agency if it enables people to achieve a life they value. Technology removes limitations (unfreedoms) to achieving a state of well-being for the user. Critical theory of technology (Feenberg, 1991) regards that technology is not neutral and represents power, even more potent than political power. While technology enhances capabilities, it can have its downside as noted in India; with the provision of ultrasound technology for rural hospitals. Female foetuses are aborted to avoid paying dowry and this sex-selection perpetuates gender discrimination (van den Hoven and Oosterlaken 2008).

At the foundation of technology is science education. Technology as a capacity for human action can be seen in primitive forms where its development was not informed by science (Adas 1989), in pre-19th century Africa. Science education accelerated the dynamism of science-and-technology to the extent that now there two are inseparable, feeding off each other for mutual growth.

2.4 Why a development perspective for this study

At the top of the Human Development ranking (2010), European countries have the highest level of development and they also have the highest number of scientists, engineers and technicians per capita. Research concludes however that more scientists are needed in many European countries (EU High Level Group, 2005); the need for scientist is far greater in the poorer countries of the world. The Organisation for Economic Co-operation and Development (OECD) countries spend more money and time in science and technology research than the total financial output of 61 poor countries of the world (Malcolm *et.al.* 2001). This large difference in capital expenditure and output in science and technology may have many underlying historical and Eurocentric reasons as many would like to think (Adas, 1989; Gordon and Sylvester, 2004). The principal fact on the ground is that for Zimbabwe and other developing countries to feed themselves and raise gross national incomes and standards of living of their citizens, science and technology needs to be addressed urgently. It starts with science education in the school system and feeds graduates into a system of progressive learning and technology creation. This progression must keep producing new ideas, material products and person power to sustain the development of science education. The question about science education in African countries is one of relevance and satisfying the expectations and aspirations of learners.

Having identified science and technology as vehicles of development, it is important to establish how science education can be made relevant to the needs of the people of Zimbabwe and the developing world in general. The central role of science education in empowering individuals and hence nations is well established (Sjøberg, 2004; Adas, 1989).

Learners and their communities are beneficiaries of the science education curricula. Through educating them it is hoped that their minds open to wider views and new knowledge. The ability to think creatively empowers the learners to act on elements within their environment to transform their lives. A study of their perspective on science education and its relevance is necessary to give the learners a voice in its discourse. Such a voice if taken into consideration could inform the debate and thinking about the efficacy of Zimbabwean science education. The purposes of science education all add up to creating opportunities for learners to become more capable of understanding and acting, thus freeing them from ignorance and incapacity.

2.4.1 Knowledge matters for development

Historical development of technology has shown how hunter gatherers were transformed into more domicile people after the emergence of crop growing techniques. Food availability became higher and it subsequently supported a higher population growth and more complex social organisation (Lewin, 2000; Ziman, 2000).

Zimbabwe and other developing economies are principally agrarian with significant levels of exploitative mining and export of raw and semi-processed materials. The low key development of processes and techniques of adding value to exports results from correspondingly low key investment in science and technology research and development. In comparison the transformation of economies from low key to high emphasis on knowledge has dramatically transformed South East Asian economies which were pretty much the same as African economies only fifty years ago. Indeed most developed economies are knowledge driven (EU High level group, 2005). Lewin elaborately argues for science education as a necessary though not sufficient condition for development; knowledge matters for development (Lewin, 2000). This idea was reiterated at the G8 Summit (2005) in a joint statement by world-wide science academies noting that;

> *…without embedding science, technology and innovation in development we fear that ambitions for Africa will fail (G8 Summit, 2005).*

Survival in business for most technology based industries worldwide (which is vast) depends to a large extent on the competitive edges they have above similar products through scientific research and development. Lewin (2000) argues that it is investment in science from secondary school and beyond that tends to have the most impact on economic development. This is realising that economically productive research and development (R&D) requires that personnel be educated mainly at secondary and tertiary level. It is also observed that these few professional scientists are generating science and technology products for the consumption of the whole world. However, the rest of the people who are not in cutting edge science activities still need to be literate in science enough to be able to consume the products of science.

Table 2-1 *R&D personnel per million for countries in this study*

(Source: Human Development Report 2006)

HDI rank 2003	2006	Country	R&D personnel per million	Population (2003 est.) (millions)
1	1	Norway	4,442	4.6
2	2	Iceland	6,592	0.3
6	5	Sweden	5,171	9.3
12	10	Netherlands	2,826	16.1
13	11	Finland	7,431	5.2
14	15	Denmark	4,822	5.4
11	7	Japan	5,085	127.7
	18	United Kingdom	2,691	59.3
62	65	Russian Federation	3,415	144.6
61	61	Malaysia	294	24.4
57	57	Trinidad and Tobago	347	1.3
120	121	South Africa	192	50
127	126	India	120	1070.8
144	145	Uganda	25	26.9
149	149	Lesotho	42	1.8
145	151	Zimbabwe	..	13
147	146	Swaziland	..	1.1
131	131	Botswana	..	1.8
138	136	Ghana	..	21.2
139	137	Bangladesh	..	136.6

Table 2-1 shows an important comparison of the level of human development as measured by the Human Development Index. High ranking countries in HDI show a corresponding high number of personnel in research and development. Most OECD countries have much higher numbers of personnel in R&D compared to Zimbabwe. The absence of personnel data for some developing countries is in itself an indication of the need for bringing up information gathering and processing to reliable levels in these countries. Generally there is a decrease in the number of personnel in R&D down the HDI ranking list.

2.4.2 Science education and person power development

One of the focal points of education policy in Zimbabwe is the training of person-power for the labour market. Whether school graduates get into employed labour or become entrepreneurs, the primary function of school science is to empower them with a functional literacy in science. Attitudes towards science and scientific attitudes are critical consequences whether the students grow up to become scientists or are engaged in any other economic activity after secondary school. In efforts to advance the practical skills of school graduates, pre-vocational and vocational schools, providing real world skills are promoted in many countries. Skills on offer in such institutions tend to get more sophisticated as the demand for diversity in skills becomes a comparative advantage for individuals in the search for less and less jobs.

According to Zim-online, as of March 2005, an inflation rate of 782% in Zimbabwe and unemployment estimated to be over 80% (2006, March 9) the labour market was unimaginably oversubscribed by competent people who could not get jobs. Brain drain becomes a significant feature in such depressed economic indicators. The economic gains of science education programmes over the years were quickly lost from Zimbabwe and destination countries benefited from the brain gain. Rapidly changing global economic parameters make long term planning and implementation of programmes for science education for the labour market to be very delicate. With globalisation, science education aims, programmes and products have become more and interchangeable with different countries. The benefits and consequences of activities in one country have implications for human development in several countries on the globe. The critical issue for Zimbabwe and other developing countries is that with their prevalently soft currencies, the human capital output of the science education process is eroded by the net outflow of skills to countries that have stronger economies, jobs and security for the Zimbabwean graduates. Regrettably the aid that is extended by rich countries in education and training grants and loans returns to the same rich countries in the form of productive people, who easily get citizenship there and never go back to develop their home country.

Relevance is a complex issue importing the sense of context, importance and practicality into the real life practice of science. Keane (2005) acknowledged that relevant science education 'is wider than *(mere)* cognition.' In searching for the meaning of relevant science education to the people who consume its products, several questions need to be borne in mind. Science education is connected with practical life experiences in several dimensions. Skills, content and the methodologies of science education shape meaning for the life of the learner as an individual, a member of the community, a citizen of his or her country and the world. In this regard, society demands practical utility of science education. A direct relationship stands out with the capabilities approach. The goals of relevant science are the same as what CA tries to achieve.

2.5 Conclusion

Science education and innovations in science and technology pervade all spheres of life. The ability to use science to solve some various challenges in life makes the difference between the might of nations. The degree to which learners can apply knowledge on challenges measures how much they are capable of living the life they value. Application of science and technology is also the main reason why Europe and America developed further than African countries. Nussbaum related education and capabilities by showing that education develops knowledge and cognitive skills which empowers people to act on circumstances. It is also important to note that good attitudes are also developed in undergoing relevant education. Education also develops capabilities in the kind of actions people take about their own lives, bodies and control of the environment. Interpersonal skills are developed through education and the sum total is empowering the learner to be in control of their world. Whatever sphere of life they choose to focus their energies in; the capabilities that are developed in school have to be relevant to their needs.

Through science education, science and technology more real opportunities have emerged for the nation and it frees people from poverty, famine and disease. For Zimbabwe, development remains a critical goal and every effort goes into developing the nation.

Views and attitudes that learners develop at school carry them through the rest of their lives. The science education they learn at school gives them the scientific literacy that forms their capabilities to live in an increasingly technological world. The momentum of technology advance is getting even higher with further research every day. Therefore it is imperative that learners be considered as a major stakeholder in thinking science education. In the future, people will need more information processing skills, knowledge and use of machinery more than today. By providing irrelevant science education, we are denying future generations of capacity to take meaningful responsibility of the earth in future.

Zimbabwe is lagging way behind first world countries in implementing modern a ‘standard of living’ Youthful learners desire a world that is peaceful, healthy and much better engineered in all ways, scientifically, socially and politically with a cleaner environment. All these elements will need to be achieved by an education that helps the learners to be and stay motivated, focused on capabilities and freedoms that will help them cope now and in future.

Chapter 3
Methodology

3.1 Introduction

This chapter introduces the Relevance of Science Education (ROSE) as the main study from which the Zimbabwean data is framed. The background, pilot and the structure of the ROSE instrument are described. Use of the instrument is also recorded in the context of ethical consideration and limitations experienced in the study. The statistical procedures used in the study are predominantly descriptive. Data reduction was done to determine trends within the data.

3.1 The Relevance of Science Education (ROSE)

The study of Zimbabwean secondary school children's views about science education and S&T was conducted as an integral part of an international comparative study called the Relevance of Science Education (ROSE). The ROSE study was designed and organised by Professor Svein Sjøberg assisted by Camilla Schreiner of Oslo University starting in 2002.

Thirty five countries from several major world regions (Europe, Asia, Africa, India, and Middle East) participated in the ROSE project, using the same questionnaire to find what learners from around the world want to study in science and how science education affects their perception of the world. The study elicits the voice of the learner about science and technology, the environment and generally tries to establish what and how the young learners' worldview is influenced by science. It is hoped that outcomes of this research influences debate in science education. It also helps to unearth issues that were previously not known about how learners view science education and science and technology as part of the fabric of life in different countries.

This thesis is a result of the Zimbabwean participation in the ROSE project. All the data collected in Zimbabwean schools is part of the larger international pool from which country comparisons have been done in other publications (see Schreiner 2006). While the focus of this thesis is on the views of Zimbabwean children, comparisons with children from other parts of the world will be made throughout the discussion. International comparison is based on the understanding that issues that affect Zimbabwean children also exist elsewhere and patterns can be interpreted from a more global perspective. The ROSE study focused only on the voice of the learners. Listening to the learners may address ideas that have been overlooked by not eliciting the voice of the learner.

3.2 Pilot to the ROSE

A forerunner of the ROSE study called *Science and Scientists* (SAS) was conducted in the late nineties to study children's interests and perceptions of science and scientists in 21 different countries (Sjøberg 2000). 30 researchers worked with a total of 9300 children of average age 13. The SAS study sought to explore the teaching of science to children in a way that took cultural diversity into consideration. Meanings of science and scientists in children were found to vary widely between high and low income countries. Scientists were generally viewed positively by children from poorer countries in contrast to children from rich countries who viewed scientists negatively. Children from rich countries tended to show low levels of interest in issues about science and technology, unlike those from poorer countries.

Children had many balanced views of the good and bad aspects of science and scientists emanating from their everyday experiences. It emerged that children's images of science are constructed from their experiences and these should be considered in science teaching to make it meaningful. An important observation was that children from poorer countries expressed high interest in learning than from rich countries. This seemed to be founded on the belief in poor countries that education is a privilege and they had to strive to achieve. In richer countries where education is readily available children were less interested in learning.

A second important outcome from the SAS study was the profiles of experiences and images of science held by children varied widely across countries and gender. Experiences appeared to make children in rich countries rather sceptical of scientists, associating them with inhumane and undesirable acts. Otherwise, children in poorer countries regarded scientists more positively as helpful and humane. These contrasts have significant influences on the manner in which children learn science.

3.2.1 Significance of the SAS study

The data from the SAS study could not give answers why there was a poor image of science among children in countries where society is significantly influenced by science and technology. However the low interest trend could be used to understand declining enrolments in science disciplines at tertiary level.

The international approach in the design of the SAS study allowed useful comparisons across different cultural and economic backgrounds of learners. It also showed the viability of international collaboration of researchers pursuing the same research program in different cultural and economic contexts to pursue diverse questions. Results from the SAS study provided empirical evidence about children's interests, hopes and aspirations and curriculum content emphases in different countries. Such information made it possible to use children's images of science to enrich and influence the debates and transform ideas in science education internationally. The SAS study resulted in several publications and more importantly, it successfully paved the way for a bigger international comparative study which became known as the Relevance of Science Education (ROSE).

3.2.2 Underlying principles of the ROSE

The ROSE project (Sjøberg 2004) seeks to study the affective perspectives of learners across many cultures in a way that:

- *respects cultural diversity and gender equity*
- *promotes personal and social relevance*
- *empowers the learner for democratic participation and citizenship*

It is believed that the empirical analysis of views solicited from learners of comparable ages around the world could give practical guidance to the many debates in science education such as priorities in curriculum design, motivation towards science and generally improving the efficacy of the science education enterprise.

The expectation of science as a vehicle of African social and economic development is well documented (Lewin, 2000; Zimbabwe Science and Technology Policy 2002, World Conference on Science, 2000, Africa's Science and Technology Plan of Action, 2005). Practical achievement of the purposes of science education in human development starts with successful implementation of science education in the schools. Learners are the most critical stakeholder in the science education discourse and a study of their views is critical to giving them a voice to be included in the curriculum reform debates in different countries. Comparison of views of children from other countries can be made if they respond to the same set of questions. This is important to discern any trends in affective perspectives across different cultural, economic and political settings of life experiences. While peoples are separated by geographical space, contact between different people is increasingly frequent and intimate through information, trade, physical movement between peoples and the need to cooperate on several global issues. Science and technology remains the one natural factor that unites different people. Thus the international character of the survey is justified by the universal nature of thought in science and technology.

3.3 The ROSE Questionnaire in Zimbabwe

Methodological approach of the ROSE survey is a special design of a section across cultures at a particular time. The ROSE study was founded on commitment of researchers in individual countries to the purposes of the study. Such commitment meant that the researchers from most countries could fund their own expenses. A few countries like Zimbabwe and other African countries needed financial support to print and distribute the questionnaires. The overall effect was to keep the cost of the ROSE very low. In comparison with other cross cultural surveys such as PISA or TIMMS, the ROSE survey was a considerably low cost study.

The Rose Questionnaire (Sjøberg and Schreiner 2004) was used to obtain data from the sample in Zimbabwe and other countries. All other countries used the same instrument. More questions could be added in various countries to obtain more nominal data about the specific samples, but the core questionnaire remained unchanged. In the Zimbabwe sample, no translation was needed because the population is English speaking. In this study, seven hundred and fifty three (753) valid questionnaires were returned from twenty-one (21) Zimbabwean secondary schools.

Different strategies were used to collect data from schools in Zimbabwe. When faculty staff travelled to schools on Teaching Practice supervision, I also could travel as I was on the staff, to schools where I would be allowed into a class for the purpose of administering the ROSE questionnaire. A second method involved sending questionnaires by courier to a colleague who administered them in Bulawayo the second largest city in the west of the country. A third method is where I travelled to schools by public transport, at the height of severe fuel shortage in the country. The use of public transport was the most difficult approach because it required many hours of waiting for the bus and sometimes it would not come because of one problem or the other, usually fuel shortage. It involved having to stay over in the field because it was difficult to keep appointments with schools. Use of public transport was then discontinued because the return rate was low and did not justify the difficulty, use of finances and time.

The questionnaire served several of purposes in the Zimbabwe sample:

- To collect information about the same questions from a large sample of people in different places incurring very low costs
- To listen to diverse learner views
- Detect trends in issues across populations

For practical purposes a meaningful sample is identified, whose answers can be generalised to the sample population. Trends that emerge from the analysis of learners' responses can be interpreted in many ways, depending on the perspectives of the researcher. Meanings that can be deduced from the total sample of responses are not necessarily always exactly what the individual learners may think. Trends are common outcomes summed over a range of responses. Interpretation of the data depends on the responses given, the context of the respondent, nature of the research instrument and attitude of the researcher. There is no one absolutely correct way of interpreting the thoughts of seven hundred answers to a question because the reasons leading each respondent to any one choice of response are different.

3.3.1 The quantitative character of the ROSE instrument

The ROSE questionnaire outlines that each response is not viewed as a correct answer as such, but one that closely agrees with the view of the respondent.

> *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.*
>
> *(ROSE questionnaire 2003)*

The implication of this statement on the questionnaire is that the questions are not asking for responses based on numerical considerations as such. It also pre-empts the tendency to unconscious distortion of responses. By assuring the respondent that every answer is important, the respondent is more likely to put their mind to read and respond seriously.

It must also be realised that while the ROSE questionnaire is asking for preferences, the total effect of the questionnaire is a combination of both qualitative and quantitative postures. Questions from Section H ask for experiences (See Appendix for the whole questionnaire). Answers to questions about whether one has done something often or rarely give us two bits of information: firstly, that the respondent has or has never experienced something and secondly, a measure of the frequency of an experience. There exists a non-disjunction of the qualitative and quantitative character of these questions.

Table 3-1 Excerpt from Section H of ROSE questionnaire

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*	*Lo never*	*Lo often*	*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	☐	☐	☐	☐

All responses in the ROSE questionnaire have the same structure of four options in a range from a negative to a positive extreme: *Never-Often, Not interested – Very interested, Not-important – Very important.*

For each of the variables in Table 3-1 a respondent may never have had such an experience in their whole life. Such a condition fits them in the '*Never*' end of perceived continuum. The scale asks the respondent to picture a range of frequency of an event (never-often), then assess his own experiences and select an appropriate position on this range to describe his own case. If they have 'visiting a zoo' once, this may be regarded as '*low never*' when the respondent meant 'rarely'. If the respondent visited a zoo three times in their whole life, one does not have a reference frequency to decide if this can be regarded as '*often*'. However, the ROSE questionnaire simplifies the response process by seeking to qualify all these measures by relying on the common usage of terms. When a scale of *'Never'* to *'Often'* appears, the sense of a spectrum is expected to be apparent, especially to a 15 year old secondary school child. Quantitative expressions of experiences may not necessarily be able to capture fine differences between qualitative measures of their experiences. However, the use of a large number of questionnaires in each country caters for such differences and statistical tests can be reliably used (Pallant, 2001).

In the different sections of the questionnaire, one basic format of the responses continuum is maintained with appropriate syntactic modifications for different contexts. Numbers 1 to 4 are used to denote the four options to the variables. These numbers do not have a quantitative significance as such but are useful labels for exploring the responses given. In the majority of variables, the numbers used in the ROSE questionnaires are non-parametric in nature. Levels of interest or degree of agreement with a given assertion exist on a continuum from one extreme (positive) to the opposite extreme (negative) or the opposite direction. It is not possible to establish an objective scale that will produce an absolute measure of aesthetic value or affective regard for an issue. However, numerical labels can help the researcher sort out the general trend of like and dislike between boys and girls in different schools and countries.

3.3.2 Likert scales.

The ROSE study uses a 4-point Likert scale throughout all the sections of the questionnaire. The ROSE questionnaire asked respondents to indicate what they would want to learn. 108 questions in Sections A, C and E are assigned values from 1 (not interested) to 4 (very interested) allowing the respondent to indicate their choice in a 4-step range. Research shows a wide range of Likert scales with points that range from two to a hundred Cummins and Gullone, (2000). Three significant psychometric properties of Likert scales are reliability, validity and sensitivity. Most research tends to emphasise on reliability and validity. Sensitivity is an intuitive perception of the levels which can be used to express an attitude. More Likert points imply a higher discrimination capacity of the scale. Cronbach (1946) in Cummins and Gullone (2000) found more composite groupings of factors from a 7 point scale than a 5point scale. However, he also concluded that scales of fewer points tend to make the response time shorter in large surveys.

3.3.3 Forced choice

Unlike odd numbered Likert scales, there is no option of *'undecided'* or *'neutral'* throughout the ROSE questionnaire. Studies of responses made to Likert scales show a tendency of respondents to shy away from making a decision and take refuge in the 'neutral' option (Deschamp & Tognoloni, 1983). Even numbered point Likert scales avoid the 'neutral' option and hence force the respondent to make a choice out of the four available. This was considered and found not to be critical because the 'neutral' option still exists in the middle of the range from 1 to 4 and does appear in the analysis of responses from the large number that participated. The intention of the ROSE questionnaire is to avoid known complications in interpreting the neutral option in the scale (Schreiner and Sjøberg 2004, Oppenheim 1992, Cohen et al 2000). ROSE questions are used to deduce salient attitudes which cannot be directly measured. Arguments against Likert scales in preference for differential semantic scales (Thomson and Shrigley, 1986, Ajzen & Fishbein, 1980) would have made it difficult to ensure consistency of the instrument after translations into different languages. The choice of the 4 point Likert scale was arrived at after extensive consideration of the intended purposes of the ROSE questionnaire and the clarity implications of using other scales (Schreiner, 2006). Its cross-cultural outlook necessitated simplicity in answering, analysing and yet being adequately informative to allow reliable interpretation.

Distortion of responses

Research has shown that when using Likert scales respondents sometimes distort responses from true scores without necessarily being aware of it (Ones, Viswesvaran & Korbin, 1995). Four distortion patterns are most commonly found in responses to Likert scaled items:

- Social desirability responding- where the respondent will choose those options that are deemed to make him or her perceived in a positive manner.
- Acquiescent responding where the respondent tends to agree to most items.
- Negative responding is when the respondent has low self-esteem and tends to respond negatively to most items, being disinterested in whatever is going on around.
- Central tendency bias, where respondents tend to avoid extreme responses, choosing to remain in the middle of the scale.

The forced choice format in the ROSE questionnaire is designed to reduce such biases. Very similar questions are presented as separate items that are spread around the questionnaire. Responses on the 4 point Likert scale keep the same variation and respondents are forced to make a choice between fairly distinct choices. Sjøberg and Schreiner make a detailed explanation of all the considerations of competing arguments (Sjøberg and Schreiner 2004).

Midpoint of the Likert scale

From the position taken to exclude a 'neutral' option in the Likert scale, it may seem that respondents have nowhere to indicate if they genuinely do not wish to make a decision concerning a particular item. From averaging the hundreds of responses, a mid-point value emerged at 2.5. Again the use of numerical calculation and attachment of meaning to the value 2.5 is justified in the sense that the averaging is a mechanism for placing the group sentiment on a scale from 1 to 4. **Table 3-2** below shows a representation scheme used throughout the ROSE items to show how responses averaged over the scale. The midpoint of the scale suggests that there are as many people choosing values on either side of 2.5. Values below 2.5 indicate responses that are regarded as negative and above 2.5 indicate a positive attitude.

In the design of the questionnaire, certain underlying constructs are expressed in several similar items that are spread around the different sections. **Table 3-2** is an excerpt from *Sowing the seeds of ROSE* (Schreiner & Sjøberg, 2004) showing the intended classification of questionnaire items at the outset of the study. All the core questions of the ROSE were administered in Zimbabwe their original form.

Table 3-2 Initial classification of questionnaire items by Sjøberg and Schreiner (2004)

A1: *U*	**A2:** *C*	**A3:** *G*	**A4:** *G*	**A5:** *G*	**A6:** -
A7: *H*	**A8:** *H*	**A9:** *HY*	**A10:** *HY*	**A11:** *H*	**A12:** *A*
A13: *A*	**A14:** *AZ*	**A15:** *P*	**A16:** -	**A17:** *C*	**A18:** *LHQ*
A19: *LM*	**A20:** *LA*	**A21:** *S*	**A22:** *UZ*	**A23:** *UZ*	**A24:** *GZ*
A25: *GZ*	**A26:** *HQZ*	**A27:** *AZ*	**A28:** *PZ*	**A29:** *CHZ*	**A30:** *CZ*
A31: *CZ*	**A32:** *CHZ*	**A33:** *EHZ*	**A34:** *UM*	**A35:** *UM*	**A36:** *LH*
A37: *HF*	**A38:** *HF*	**A39:** *CHF*	**A40:** *HF*	**A41:** *HF*	**A42:** *LHF*
A43: *SH*	**A44:** *UT*	**A45:** *UT*	**A46:** *LHQ*	**A47:** *CT*	**A48:** *CT*
C1: *CR*	**C2:** *LT*	**C3:** *LT*	**C4:** *ST*	**C5:** *T*	**C6:** *T*
C7: *T*	**C8:** *UM*	**C9:** *UMH*	**C10:** *UM*	**C11:** *HM*	**C12:** *HQM*
C13: *HM*	**C14:** *M*	**C15:** *HM*	**C16:** *LUB*	**C17:** *LGB*	**C18:** *GB*
E1: *PB*	**E2:** *LGB*	**E3:** *GW*	**E4:** *GW*	**E5:** *GW*	**E6:** *TW*
E7: *HQ*	**E8:** *HQ*	**E9:** *HQY*	**E10:** *HQ*	**E11:** *HQ*	**E12:** *HY*
E13: *HY*	**E14:** *HY*	**E15:** *HY*	**E16:** *AW*	**E17:** *PR*	**E18:** *PHQ*
E19: *PW*	**E20:** *EW*	**E21:** *EW*	**E22:** *CR*	**E23:** *HY*	**E24:** *AR*
E25: *PR*	**E26:** *CR*	**E27:** *ER*	**E28:** *TR*	**E29:** *UX*	**E30:** *EX*
E31: *HYX*	**E32:** *HQ*	**E33:** *WX*	**E34:** *MX*	**E35:** *RHX*	**E36:** *X*
E37: *X*	**E38:** *XZ*	**E39:** *MX*	**E40:** *X*	**E41:** *X*	**E42:** *X*

Table 1: Item numbers (bold) and intended connections to contents and contexts (italics). Abbreviations: U: Universe; G: Geo science; A: Animals; P: Plants; C: Chemicals, L: Light, etc.; S: Sounds; E: Energy; T: Technology; Z: Hullabaloo; H: Human biology, Q: Health; F: Fitness; Y: Young body; M: Mystery; B: Beauty; W: Environmental protection; R: Everyday relevance, X: STS, NOS, etc. A few items are only given a dash, as they were not categorized in these contents and contexts.

3.3.4 Free response item

Section I of the ROSE questionnaire asked a free response question about what the students would like to research on if they were scientists. They would also explain why they chose a particular topic to research on. This item is viewed as an extension of the A, C and E items asking what the children would want to learn about. The Likert type items in A, C, E imply learning in a class setting with a defined curriculum. Research interests are also an expression of the learning interests and are a good measure of the voice of the children because they say it without the guidance of Likert options.

3.4 Selection of respondents for ROSE study

Twenty one schools participated in the ROSE study in Zimbabwe. The schools were selected along the central region of the country (the Great Dyke). This region is generally accessible and cities like Bindura, Harare, Gweru and Bulawayo are on this highway. At each school the penultimate class to the end of compulsory secondary education (Form Three) answered the questionnaire. A total of 735 individuals were involved.

3.4.1 Age of respondents

At Form Three in secondary school, learners were expected to be of average age 15 years. The ROSE study targeted the same penultimate school year in all the participating countries. For the comparative analysis of the international ROSE data, the average age was understood to depend on each specific country. In Zimbabwe, ages of children could vary widely due to class repeaters and late entries into school. The penultimate year of compulsory secondary education is the more consistent parameter that was considered in administering the questionnaire.

Table 3-3 Gender* Age distribution of all Zimbabwe respondents

gender	age							
	14	15	16	17	18	19	20	Total
girl	5	91	214	77	7	1	1	396
boy	7	73	142	89	12	4	0	327
Total	12	165	356	166	19	5	1	724

3.4.2 Gender

For many of the issues considered by the ROSE questionnaire, responses are likely to be influenced by the gender equity regimes in different countries. For a variety of reasons, access to education is not always the same for boys and girls in many countries. Contrast between boys and girls is a major strength of the ROSE and attitude variations are very significant when expressed by a fairly large number. The ROSE questionnaire does not make an assumption that the number of boys and girls are equal but rather that both sexes are afforded equal opportunities to engage in a science education which is relevant to their needs. The ROSE questionnaire makes a provision for distinguishing views of boys and girls.

3.4.3 Sample representativeness

The analyses that are done on the data assume that the sample taken is adequately representative of the studied population of Zimbabwean schools. Both boys and girls were represented in the sample according to their natural distribution in the population. Literature on sample reliability (Ajzen and Fishbein, 1980) regards that a sample of between 10 and 20% of the population is regarded as an adequately reliable sample of the population. A total of 21 schools were sampled and out of these, schools with four streams of the penultimate class meant 25% of the pupils were involved. For schools with one stream of the penultimate class, 100% of the students participated. Overall sample is therefore well over 20% of the total possible number of penultimate class students who could have responded to the questionnaire.

There are sections of the Zimbabwean population which are not represented in the survey. These are the minority groups in the Zambezi Valley floor. The valley is inhabited by the Nambya, and Tonga people. The cultures and languages of these groups are very different from the major groups in the country. Living conditions in the Zambezi valley are in the extremes. There are high temperatures, and the Rift valley ecology enables lifestyles that are very different from the rest of the country. Radio, television and now mobile phone communication links are generally quite difficult to reach people at the base of the valley floor. The low infrastructural development of the valley makes it remote and inaccessible to many studies undertaken in the rest of the country. Therefore, the current ROSE study in Zimbabwe was severely limited in failing to get access to these people who would represent the part of the Zimbabwean population who are pretty much left behind from modernity. Minority languages have only started being written in the ten years. Views of such children concerning science and technology would be very interesting to explore, maybe in another project.

3.4.4 Data reduction of Items

Data reduction of the 255 ROSE questionnaire items was done using factor analysis. Explorative factor analysis seeks to group items according to underlying structures within a large number of variables. For a characteristic within the respondents, certain variables tend to group together into a recognisable set. The actual labelling of the characteristic depends on the assessment of the researcher and is often influenced by the conceptual framework of the researcher.

Questionnaire items were designed with a certain inherent classification. The nature of factors is that they are unique to the sample rather than the questionnaire. Factors from Zimbabwe sample differ from what emerges from another country. The Principal components factor extraction method was used with Direct Oblimin variation.

Factor analysis is necessary to study the way different items overlap in the formulation of interests. The extent to which each group of factors bind together is indicated by the Cronbach-α. Literature shows that Cronbach-α values in the affective dimension are usually lower than objective variables like performance scores (Smith and Glass 1987, Roberts and Clifton, 1992). Cronbach-α ranges from 0 to 1 and where factors are closely associated a high α-value ranging from 0.7 and above is expected.

3.4.5 Frequencies

The variables in the different sections of the questionnaire were analysed for indications that are consistent with intrinsic desires of children. For each section, the frequency of choices or factors generated from there tends to show the popularity of a concept.

Drop-line graphs were composed from the mean responses for each item and factor analysis outputs. Plotting the mean value for boys and girls allowed gender comparison and shows how attitudes are gender based. Every day experiences influence the ideas to which children attach value. The variables in Sections A, C and E are classified according to a logical grouping of variables that is regarded to be consistent with the growth of specific capabilities. Groupings of skills have been made for different interests and mean scores for these have been calculated and ranked in order of descending means.

3.4.6 Independent samples t-test

In science classes, boys and girls are treated the same. However differences in attitudes formed are assumed to depend on gender stereotypes. An independent samples t-test can show if the gender difference in the attitude towards to factor is significant. While drop-line graphs can strongly suggest this significance, the position of the position of boys or girls on the graphs can be influenced by their unequal numbers. Graphical difference may not necessarily be significant but the independent samples test will tell if there is a statistically significant difference or not.

3.5 Ethical considerations

For a research that spanned more than forty countries, where different cultures, languages and traditions would interact with the same instrument, ethics was a major consideration of ROSE.

3.5.1 Informed consent

Permission was sought from the Ministry of Education to enter into schools to administer the ROSE questionnaire to a class, it was part of the standard conduct of the research, to explain the purpose of the research and invite willing participants. It was critical for students to understand that this was not a test and the results would not be used for any grading or labelling purposes. The respondents were also free to answer the questions as far as they could go. While the ideal would be to answer all questions, respondents were free to skip items which they were not comfortable answering. In Zimbabwe, there is a religious sect (Zionist Apostles) who does not believe in hospitalisation or any other medication besides what they administer in their religion. Where such children were thought to be present they were made free to skip items that asked about their experiences at a hospital.

3.5.2 Anonymity

All questionnaire booklets started with a demographic section which asked for just the gender age and name of country. No names or class number were asked for. The questionnaire front page also explains that the answers are expected to be anonymous and they should not write their names.

For analysis purposes, the questionnaires were only numbered in the order in which they came. Labels of school of origin were included in order to inform comparisons based on the location of the school.

3.5.3 Privacy

While some issues can be easily discussed in some cultures, legislature in different countries would not permit asking certain questions that are seen as invading the privacy of individuals. It would be convenient and informative to ask more about the economic status of families as one angle within which consideration of backgrounds could be made. However, questions about family incomes, education levels of parents and siblings could not be asked. Much as these questions could have enriched the discussions and analyses, it is illegal and against norms in many cultures to ask such questions.

3.5.4 Language translation

The ROSE questionnaire was designed in English. In Zimbabwe, all schools use English as medium of instruction and no translations were required. However, explanations of new terms were made for understanding of the items. Concepts like cloning, alternative therapies would be new to some students because they are not in their cultures or curricula. The ROSE codebook gave instructions to participants to carry out translations into local languages where necessary. Some items could be split up into two or more, depending on the nature of the language. Direct translations always have a mismatch in meanings in different languages and hence items could be broken up into the best possible equivalents. This part of the method is likely to have introduced some variations because it assumed that participating researchers understood the entire original English questionnaire. It is not known if translated instruments were tested for consistency with the original. The most important quality of the ROSE questionnaire is its usability. Items are generally written in clear and unambiguous language which can be understood by many children at the age of 15 to 16 years.

3.6 Administration of the ROSE project in Zimbabwe

The administration of the ROSE instrument in Zimbabwe was done in the first half of 2003. At this time in Zimbabwe had slipped into very difficult economic times where inflation eroded the purchasing power of the Zimbabwe currency. The acute economic environment made it extremely difficult to conduct research with own funding. Financial support was made available for the project from the ROSE colleagues in Norway. The principal financial requirements were the printing of the questionnaire and travelling to administer it in the various schools. To reduce costs, a hundred questionnaires were printed and these would be retrieved after every class responds to the questionnaire to be reused at the next school. A special answer grid was designed and printed on cheaper affordable paper.

There was no change to the questions, just that the respondents got an extra instruction not to mark on the questionnaire.

Travelling to the different schools was mostly by public transport and in some cases; questionnaire administration was done during official trips to schools for Teaching Practice supervision. A total of 21 schools successfully responded to the questionnaire. In three of the centres, arrangements were abortive and responses from five schools in these regions were abandoned. A possible two hundred responses were never recovered because of transport and logistical problems that could not be surmounted at the time.

Data coding and capture

The same ROSE codebook (http://roseproject.no/) was used by all participants in the project worldwide. All answer books were numbered in the order in which they came in. SPSS was used to record all the responses for analysis. Assistants were engaged for the data capture process. All responses were labelled with their appropriate numerical labels and recorded individually. This stage required very careful checking because mistakes could easily be made in mismatching numbers or entering incorrect figures.

Treatment of Errors in data capture

Numerical values of the Likert-scale were consistent through the questionnaire. Negative sense responses such as *not interested*, or *not important*, had numerical value 1. The positive sense had value 3 and 4. Missing responses were coded 9. Common errors were double entering a number in the same box simply as a result of quick finger movement across the keyboard. Frequency checks in SPSS could identify such double entries for correction. Mistakes could still be made by entering the correct value labels from the actual numbered answer script. SPSS could not tell that a 3 was entered instead of a 2. Only physical checking of the spread sheet against the physical data could identify such errors. It was very necessary to ensure that correct data was entered otherwise it would give incorrect interpretations.

Missing values arose for two reasons, either the student could not understand the question and left it unanswered or they were not decided on the available response options. The instrument did not distinguish between these two reasons and both were coded as *'missing'*.

3.7 Limitations

At first sight, the questionnaire looks large and has too many sections and items but students could generally answer the whole questionnaire within forty minutes.

The only limitation in Zimbabwe was the cost of printing it, arising from unusually desperate economic experiences of the country at the time of administering the instrument. In more conducive circumstances, more schools could have become involved.

3.8 Statistical analysis

The ROSE project seeks to describe trends of views and attitudes by learners. Descriptive statistics is used in this chapter to show the attitudes of learners in different countries. Factor analysis groups responses according to certain underlying factors which will be labelled as they emerge. This will allow detecting attitudinal trends within the selected population. The comparison of Zimbabwean learners with those from other countries clarifies the contrast with and situates Zimbabwean learners within the global flux of teenage attitudes.

3.8.1 Statistical procedures for analysing ROSE data

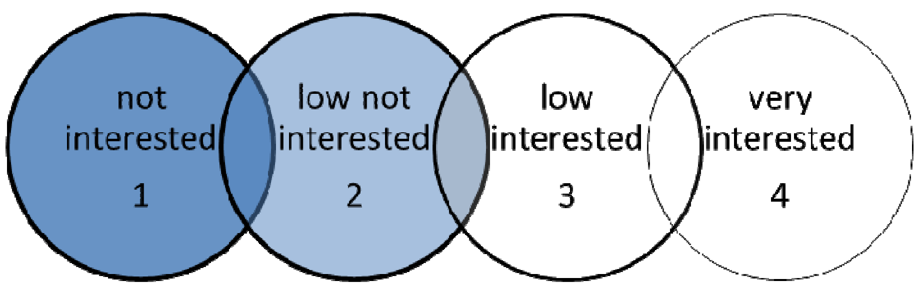
The validity of statistical analysis is based on a number of assumptions about the data and the procedures used. Description of attitudes is quasi-experimental in nature, basing on the fact that the feelings of respondents are not precisely measurable. An exploration of performance of a class after a particular pedagogical treatment would be different in that it would have a straight hypothesis and the analysis is based on an objective mark tallies. Attitudinal responses are non-parametric. Few assumptions are made about the data:

- Value labels in the Likert scale represent views that are distinctly different from each other and the selection made by the respondent is the best representation of his or her view.
- The responses are an indicator of the attitudinal maturity of the respondents.
- Data from respondents in different parts of the world is comparable despite questionnaire translations for non-English speaking respondents because all the countries used the same core items and aimed at the same level of education.
- Trends that may emerge from the different country samples are a reflection of the principal attitudes nurtured in children by the sum total of experiences in that country.
- Sample selection in all the countries took a cross-section of the different types of schools found in each country in terms of economic resources, geographical and cultural differences.

- The sample sizes in all the countries are large (n>700) such that the law of large numbers and the Central Limit Theorem are applicable.

3.8.2 Ordinal nature and statistical treatment of ROSE data

Responses to the ROSE questionnaire are ordinal. Such data can tell us that there is a progression from one extreme such as *'not interested'* (value label=1) through *'low not interested'* (value label =2), *'low interested'* up to *'very interested'* (value label =4). One cannot however tell if the distance between any two adjacent values reflects the same 'distance' in attitudinal views. Though efforts at measurement of affect exist (Edell and Burke 1987, Richins, 1997) there is no objective measure of attitude, or a model that can convert attitudinal value labels into interval data. Attitudinal measures are also specific to the attitude they are designed to measure and hence are not easily transferable. Use of **value labels** does not convey a regular interval or ratio. However, there exists a definite progressive order of levels of perception such that the values can be treated as evenly spaced in the given spectrum. A ranking scale makes an assumption 'that there is a continuum underlying the observed ranks' (Siegel 1957). The Likert scale with value labels 1 to 4 is equivalent to a progression which can be drawn and labelled *'not interested'* at one end and *'very interested'* at another.



All the four responses can be reduced to two basic options: agreeing and disagreeing. Each of these two has two levels of agreement; technically a high and a low.

3.8.3 Use of means with ordinal data

The 4 point Likert scale divides the continuum of sentiment from negative to positive into four zones. More points on the Likert scale would simply add the number of steps in the same continuum. The respondent rates his or her own feelings about an item within the given scale construct and mark a Likert option that expresses how strongly they feel about an issue. The numerical value labels 1-4 are not empirical measurements like blood pressure values or test scores (interval). Theory requires that one uses the median values to explore the data. In view of the foregoing discussion of statistical theory the median shall not be used in this study. Also, while the median can be practical for a small sample of less than 100, for much larger samples, such as the over 700 in Zimbabwe alone and more than 38 000 in the international sample, the median becomes very uninformative.

3.8.4 Justifying the use of means in ROSE data analysis

There is an unresolved debate in the application of parametric tests (including means) on ordinal data (Jamieson, 2004). The research community remains divided on the traditions and procedure used in statistical analysis yet the meaning of the data is more important than the type of the data and statistical treatment must enhance the meaning of data rather than lose it.

Since the 1950s, there has been a debate about the parametric treatment of ordinal data. This debate cannot be exhausted here, but highlights will be explored to clarify reasons why the ROSE data is analysed using means. In 1946, a hierarchy of measurement scales and their permissible statistical treatment techniques was designed by Stevens, a Harvard psychologist. The hierarchy was based on the 'invariance of their meaning under different classes of transformations'. A scale is ordinal if

> *…any transformation of the scale values that preserves numerical order produces another scale that shares the same one-to-one relation between comparisons among objects and comparisons among corresponding scale values (Velleman & Wilkinson, 1993).*

The meaning of responses in ROSE is not changed by computing means. The number of responses is large and the main underlying assumption for using means is that central tendency emerges in most ROSE items.

In one school of thought: The mean cannot be used in analysing ordinal data (Jakobsonn, 2004), because means are parametric and using means assumes equal intervals between the responses and normal distribution of the data. Another school of thought, the 'practitioner' camp, mainly made up of psychologists and educationists argue against this rigidity citing the loss in meaning by using tests that lack robustness only on the basis of data classification (Sauro, 2004). Veleman and Wilkinson (1993) also criticise Stevens (1946) that the purist rigidity 'often lead to degrading data by rank ordering and unnecessarily resorting to nonparametric methods'.

In the analysis of ROSE data, parametric measures such as the mean and others can be used for their robustness but the critical effect is in the interpretation of the outcomes of tests and treatments. One cannot conclude a ratio effect on the basis of means in the ROSE study: value labels 1 and 2 do not necessarily refer to a double measure of attitude, neither does *'low interested'* refer to half of *'very interested'*. If the deductions and conclusions remain in the realm of the ordinal meanings of the value labels, then perceived 'violations' of the Stevens hierarchy are immaterial. Means turn out to be a very sensitive measure of 'group feelings' averaged over several hundred respondents.

While there are criticisms against these ideas it is necessary to note here that classification of data in itself has an accepted role in data analysis. The nomenclature of the data types is not arguable. The measurement of the data and the questions asked are more fundamental attributes of the data rather than the classification on its own.

3.8.5 Application of taxonomy to real world data

Choice of means over mode and median is centred on graininess of data. The numerical space between value labels is important in considering the behaviour of an item over several hundred respondents. The effect of calculating means, mode and medians is shown in

Table 3-4 below. It is evident that for all responses between 3 and 4, using the mean can allow the scale to have a higher resolution such that values like 3.34 can be plotted. The scale from 1 to 4 is able to represent a smoothly progressive spectrum of attitude. Higher resolution would be possible if more decimal places are set in the Likert scale. The median however, tends to bundle everything into the 4 levels of the Likert scale only, a situation which increases the graininess of the interpretation. The median does not resolve the spectrum as much. The data resolution level which is possible by using the mean seeks only to support objective comparisons like 'which group of respondents is more positive than another?' without forcing geometric or arithmetic differences out of the data.

Table 3-4 Comparison of the sensitivity of mean, mode and median as a measure of central tendency

	N	Mean	Median	Mode
	Valid			
Age	724	16.05	16.00	16
A4. How mountains, rivers and oceans develop and change	712	2.94	3.00	4
A29. Deadly poisons and what they do to the human body	721	3.34	4.00	4
B9. Using my talents and abilities	725	3.74	4.00	4
B24. Becoming 'the boss' at my job	720	3.09	4.00	4
C14. Ghosts and witches, and whether they may exist	718	2.64	3.00	4
D8. People worry too much about environmental problems	708	2.59	3.00	4
D17. Nearly all human activity is damaging for the environment	714	2.69	3.00	4

The principal point is that ROSE can be meaningfully analysed using means and other parametric tests without compromising the rank profile of the responses. This position is corroborated by Nunnally (1967, p17) who argues that it is permissible to treat psychometric scales as if they are interval data without any harm to the study. Townsend and Ashby (1984) argued the case of 'assigning numbers to objects in such a way that interesting qualitative empirical relations among the objects are reflected in the numbers themselves as well as in the important relations of the number system.' In view of the irresolute nature of the statistical theory argument (for more than half a century), it is decided that for the ROSE data the mean is the most logical measure of central tendency. For data reduction, factor analysis can also be used and the tests of reliability and internal consistency of composite variables shall be treated without looking over the shoulder for the parametric-non parametric statistics debate.

Central tendency in the ROSE data

Statistical theory says that central tendency in ordinal data should be treated by the median. Very strong but inconclusive arguments meet the researcher on this issue (Jamieson 2004, Kuzon *et al* 1996, Knap 1990, Muijs, 2004). Some of the arguments however (Muijs, 2004) deny that measures of feeling exist in a continuum. For purposes of description, there has to be a measure of central tendency that can be relied on to give a trend of views across all the respondents. From strong disagreement to strong agreement there is really a continuous scale which can be broken into more steps than the four points used in the ROSE. Muijs (2004) would rather the median be used because it gives integral values only. However

Table 3-4 shows how this would lead to loss in meaning. For the more than 700 respondents in Zimbabwe it makes a finer resolution of attitudes on the *agree-to-disagree* spectrum. For a small number of respondents (<100), the median could be used.

3.9 Conclusion

Statistical analysis seeks to organise raw data and explore latent meanings. There is almost no limit to the amount of information that can be gleaned from the high amount of raw data found in the ROSE study. However the art of statistical analysis is a realm in itself with its own debates. The classical debate of using parametric treatment on ordinal data is one that is not about to be concluded (Schreiner, 2006). In view of the strong arguments associated with this debate for either school of thought, most of the analyses done in this study are mainly simple explorative descriptions. It is not the intent of this study to participate in statistical theory arguments but to use the procedures which can convey meaning to the readers of this study.

If preferences are described in percentages or simple bar graphs, it is simple enough to convey the comparative essence. Graphical representations of Likert scale means are also used because they convey meaning and a convenient way of dealing with more than 38000 responses from the 27 countries selected for comparison in this study. Above all the drop-lines (SPSS) have a graphic impact which quickly conveys direct contrast between countries in a simple manner.

Chapter 4
Results

4.1 Introduction

This chapter looks at the results of various research questions. It explores the Zimbabwean data to obtain a picture of the attitudes of secondary school learners. Various questions are presented in data form to determine trends that exist in the sampled schools in Zimbabwe and where necessary, international comparisons.

4.2 Research Question 1: What are the interests of secondary school learners in science?

4.2.1 Most popular items

The following tables show ten most popular items in Sections A, C and E (What I want to learn about) from the Zimbabwe sample. Mean values are average of the Likert scale from 1 to 4. Mean values place the average response for all the respondents. Missing values are not computed as a software default.

The ten most popular items from each section are combined for both sexes. This combination enables observation of the responses without any gender difference. Mean values may however appear simply because there are more girls who chose a given response more than boys. Also interests of boys are different from girls. Therefore it is important to look at most frequent responses on a gender basis.

Table 4-1 Mean values of top ten responses from Sections ACE "What I want learn about": Zimbabwe

Top ten responses in Section A	Mean
A37. What to eat to keep healthy and fit	3.49
A9. Sex and reproduction	3.45
A7. How the human body is built and functions	3.45
A40. How to exercise to keep the body fit and strong	3.42
A29. Deadly poisons and what they do to the human body	3.34
A32. Biological and chemical weapons and what they do to the human body	3.27
A36. How the eye can see light and colours	3.22
A26. Epidemics and diseases causing large losses of life	3.21
A33. The effect of strong electric shocks and lightning on the human body	3.20
A43. How the ear can hear different sounds	3.20
C7. How computers work	3.63
C6. How mobile phones can send and receive messages	3.43
C4. How cassette tapes, CDs and DVDs store and play sound and music	3.38
C13. Why we dream while we are sleeping, and what the dreams may mean	3.38
C5. How things like radios and televisions work	3.31
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.22
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	3.20
C16. Why the stars twinkle and the sky is blue	3.10
C17. Why we can see the rainbow	3.10
C18. Properties of gems and crystals and how these are used for beauty	2.96
E9. Sexually transmitted diseases and how to be protected against them	3.66
E11. What we know about HIV/AIDS and how to control it	3.59
E23. How my body grows and matures	3.56
E5. What can be done to ensure clean air and safe drinking water	3.55
E8. Cancer, what we know and how we can treat it	3.51
E10. How to perform first-aid and use basic medical equipment	3.49
E7. How to control epidemics and diseases	3.48
E12. How alcohol and tobacco might affect the body	3.45
E32. How gene technology can prevent diseases	3.31
E27. Electricity, how it is produced and used in the home	3.30

Table 4-2 **Most popular responses by Girls to items in Sections ACE from Zimbabwe**

Items	Mean
A37. What to eat to keep healthy and fit	3.60
A40. How to exercise to keep the body fit and strong	3.54
A7. How the human body is built and functions	3.49
A39. The ability of lotions and creams to keep the skin young	3.45
A9. Sex and reproduction	3.42
A11. How babies grow and mature	3.32
A36. How the eye can see light and colours	3.28
A26. Epidemics and diseases causing large losses of life	3.28
A29. Deadly poisons and what they do to the human body	3.27
A10. Birth control and contraception	3.25
C7. How computers work	3.60
C13. Why we dream while we are sleeping, and what the dreams may mean	3.54
C6. How mobile phones can send and receive messages	3.49
C4. How cassette tapes, CDs and DVDs store and play sound and music	3.45
C16. Why the stars twinkle and the sky is blue	3.42
C5. How things like radios and televisions work	3.32
C17. Why we can see the rainbow	3.28
C18. Properties of gems and crystals and how these are used for beauty	3.28
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.27
C11. Life and death and the human soul	3.25
E9. Sexually transmitted diseases and how to be protected against them	3.73
E11. What we know about HIV/AIDS and how to control it	3.63
E23. How my body grows and matures	3.62
E8. Cancer, what we know and how we can treat	3.57
E5. What can be done to ensure clean air and safe drinking water	3.56
E10. How to perform first-aid and use basic medical equipment	3.55
E7. How to control epidemics and diseases	3.53
E12. How alcohol and tobacco might affect the body	3.47
E31. Biological and human aspects of abortion	3.40
E32. How gene technology can prevent diseases	3.39

***Table 4-3* Most popular responses by boys in Sections ACE from Zimbabwe**

Items	Mean
A9. Sex and reproduction	3.50
A29. Deadly poisons and what they do to the human body	3.42
A32. Biological and chemical weapons and what they do to the human body	3.41
A7. How the human body is built and functions	3.40
A31. Explosive chemicals	3.39
A37. What to eat to keep healthy and fit	3.36
A40. How to exercise to keep the body fit and strong	3.28
A46. How X-rays, ultrasound, etc. are used in medicine	3.28
A48. How a nuclear power plant functions	3.25
A30. How the atom bomb functions	3.22
C7. How computers work	3.65
C6. How mobile phones can send and receive messages	3.53
C5. How things like radios and televisions work	3.51
C4. How cassette tapes, CDs and DVDs store and play sound and music	3.50
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	3.47
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.40
C13. Why we dream while we are sleeping, and what the dreams may mean	3.31
C17. Why we can see the rainbow	3.12
C16. Why the stars twinkle and the sky is blue	3.04
C8. The possibility of life outside earth	2.91
E9. Sexually transmitted diseases and how to be protected against them	3.59
E11. What we know about HIV/AIDS and how to control it	3.55
E5. What can be done to ensure clean air and safe drinking water	3.53
E23. How my body grows and	3.50
E8. Cancer, what we know and how we can treat it	3.43
E7. How to control epidemics and diseases	3.43
E10. How to perform first-aid and use basic medical equipment	3.42
E12. How alcohol and tobacco might affect the body	3.42
E27. Electricity, how it is produced and used in the home	3.41
E28. How to use and repair everyday electrical and mechanical equipment	3.40

4.2.2 Least popular responses in Sections A, C and E

Table 4-4 Least popular items from Section A by girls

Item	Mean
A17. Atoms and molecules	2.69
A27. Brutal, dangerous and threatening animals	2.68
A23. How meteors, comets or asteroids may cause disasters on earth	2.65
A48. How a nuclear power plant functions	2.63
A1. Stars, planets and the universe	2.62
A47. How petrol and diesel engines work	2.62
A14. Dinosaurs, how they lived and why they died out	2.56
A44. Rockets, satellites and space travel	2.50
A12. Cloning of animals	2.30
A22. Black holes, supernovas and other spectacular objects in outer space	2.17

Table 4-5 Ten least popular items from Section A for bboys

A27. Brutal, dangerous and threatening animals	2.83
A13. Animals in other parts of the world	2.79
A14. Dinosaurs, how they lived and why they died out	2.77
A39. The ability of lotions and creams to keep the skin young	2.73
A6. The origin and evolution of life on earth	2.73
A35. How to find my way and navigate by the stars	2.69
A41. Plastic surgery and cosmetic surgery	2.63
A12. Cloning of animals	2.60
A22. Black holes, supernovas and other spectacular objects in outer space	2.52
A38. Eating disorders like anorexia or bulimia	2.45

In Section A, boys show least interest in space issues like black holes, supernovas and finding direction using stars. It is interesting that item A39 is among the ten least popular with boys yet it is among the top ten items for girls.

I suspect that the Zimbabwean respondents did not adequately understand the item A38 Eating disorders like Bulimia and anorexia. Girls in Zimbabwe were sensitive to the items that have to do with the way they look, in the topmost four items. Comparing with other countries A38 is ranking together with these four items. Possible reasons for this apparent exclusion are either participants did not fully understand the terms in A38 or that the phenomena of anorexia and bulimia are not common in Zimbabwe. Further evidence of this hypothesis is that the boys were generally not worried about such and this was evident in all countries involved.

The phenomenon of cloning is also not an everyday occurrence in Zimbabwe. All the respondents showed its low popularity. The reason for a low mean on this item could be that cloning is a high tech research issue that is not common knowledge for a sixteen year old in Zimbabwe. The curriculum had no cloning anywhere and so teenagers were not likely to know much about it from school, unless they read it in magazines, television.

Table 4-6 Ten least popular items from Section C for girls in Zimbabwe

Item	Mean
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	3.06
C11. Life and death and the human soul	3.03
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	2.96
C8. The possibility of life outside earth	2.90
C15. Thought transference, mind-reading, sixth sense, intuition, etc.	2.89
C14. Ghosts and witches, and whether they may exist	2.72
C9. Astrology and horoscopes, and whether the planets can influence human beings	2.70
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	2.58
C10. Unsolved mysteries in outer space	2.38
C1. How crude oil is converted to other materials, like plastics and textiles	2.36

Table 4-7 Ten least popular items for boys from Section C

Item	Mean
C16. Why the stars twinkle and the sky is blue	3.04
C8. The possibility of life outside earth	2.91
C1. How crude oil is converted to other materials, like plastics and textiles	2.86
C18. Properties of gems and crystals and how these are used for beauty	2.82
C11. Life and death and the human soul	2.82
C15. Thought transference, mind-reading, sixth sense, intuition, etc.	2.81
C9. Astrology and horoscopes, and whether the planets can influence human beings	2.62
C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	2.60
C10. Unsolved mysteries in outer space	2.56
C14. Ghosts and witches, and whether they may exist	2.53

Section C presented several ‘other worldly’ phenomena and alternative therapies which are generally uncommon to 16 year old learners in Zimbabwe.

Table 4-8 Least popular items from Section E for girls

Item	**Mean**
E16. How to protect endangered species of animals	2.95
E17. How to improve the harvest in gardens and farms	2.84
E19. Organic and ecological farming without use of pesticides and artificial fertilizers	2.82
E38. Big blunders and mistakes in research and inventions	2.82
E25. Plants in my area	2.69
E29. The first landing on the moon and the history of space exploration	2.69
E33. Benefits and possible hazards of modern methods of farming	2.59
E37. Famous scientists and their lives	2.48
E24. Animals in my area	2.33
E1. Symmetries and patterns in leaves and flowers	2.09

Table 4-9 Least popular items in Section E for Boys

Item	Mean
E39. How scientific ideas sometimes challenge religion, authority and tradition	2.97
E2. How the sunset colours the sky	2.91
E19. Organic and ecological farming without use of pesticides and artificial fertilizers	2.88
E33. Benefits and possible hazards of modern methods of farming	2.86
E25. Plants in my area	2.85
E29. The first landing on the moon and the history of space exploration	2.83
E26. Detergents, soaps and how they work	2.80
E37. Famous scientists and their lives	2.78
E24. Animals in my area	2.72
E1. Symmetries and patterns in leaves and flowers	2.15

4.2.3 International profile of some popular interest items in Sections ACE

Drop line graphs graph are used to display the difference in choices between boys and girls in different countries. These graphs show the general trends for choices made by boys and girls across all participating countries. Zimbabwe has its place in the international list. The general distance between genders is narrower for Zimbabwe and other developing countries than European countries.

While attitudes for some items can be similar across gender, wide gender differences are noticed in the European countries. Norway, Denmark, Czech Republic, Japan and Finland show attitudes that are opposite between boys and girls. Item A37 is chosen to demonstrate how the drop lines can distinguish boys from girls in a particular item. All girls have a positive attitude towards item A37, *'What to eat to keep healthy and fit* compared to boys who care much less than the girls. The distance between gender choices is much wider

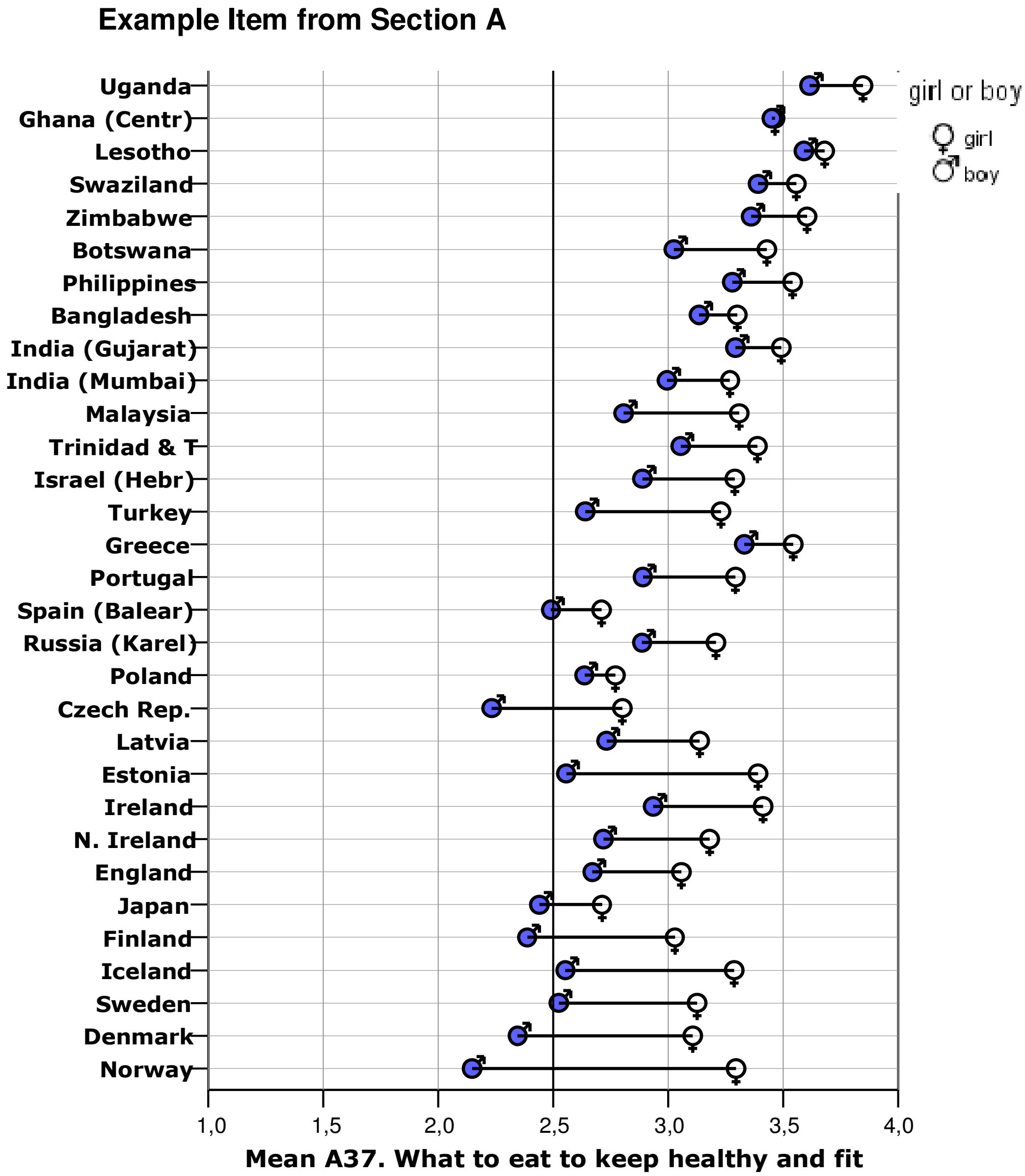


Figure 4-1 International comparison of responses to item A37

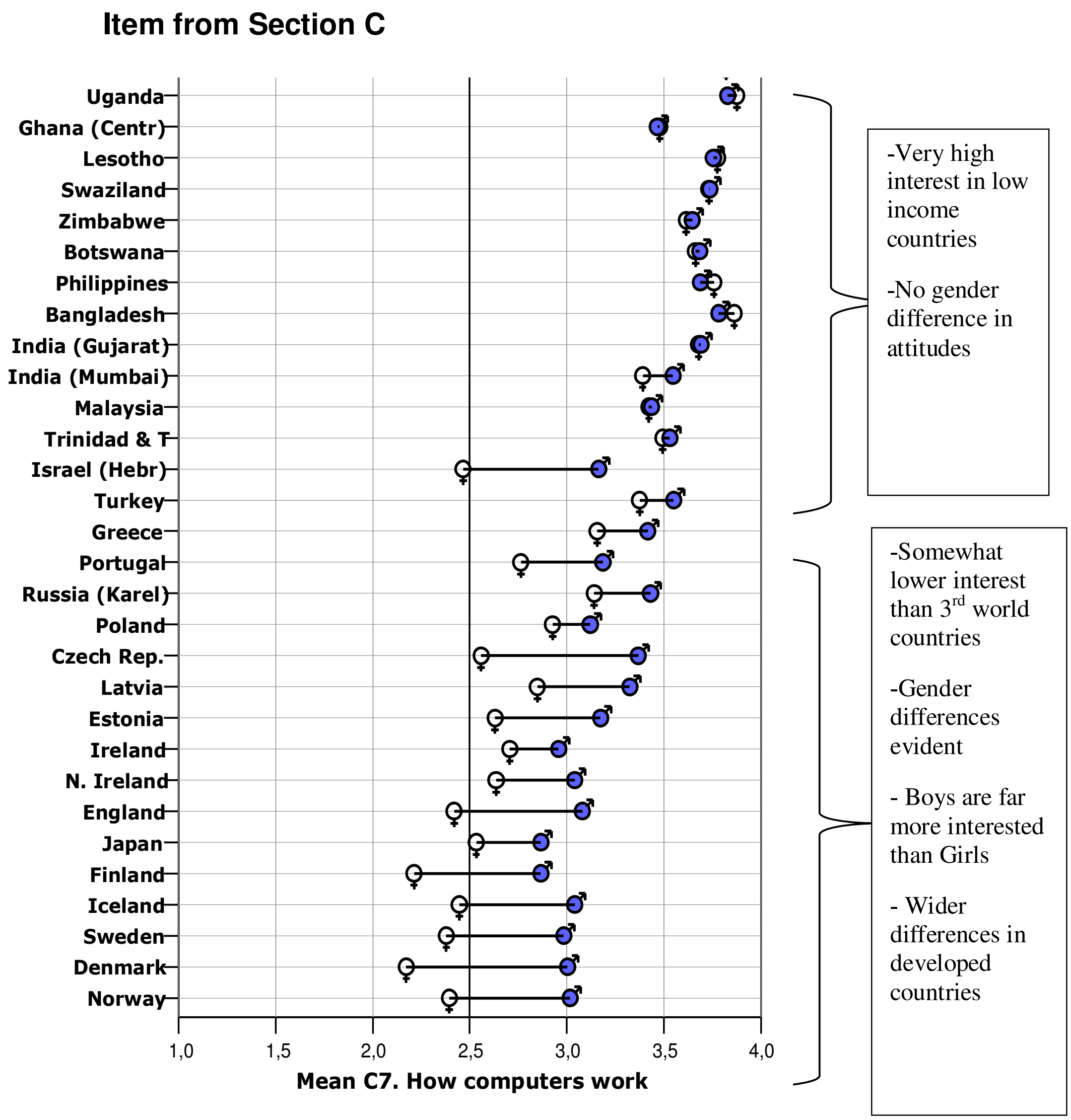


Figure 4-2 *International comparison of item C7*

- Respondents from developing 'southern' countries showed high interest across gender
- Gender difference in this attitude is negligible
- Higher income countries show wider gender differences with a distinct interest in computers shown by boys
- Overall interest level for computers is lower than developing countries

Item from Section E

- All respondents interested in item E9. All responses are above the middle of the range of Likert values.
- Girls are generally more interested in 'Sexually transmitted diseases and how to be protected against them', they have higher mean values.
- Much smaller gender differences in the developing group of countries
- Boys in developed countries seem much less interested than the girls
- Interest in sexuality may suggest earlier maturity of girls than boys in sexual matters.

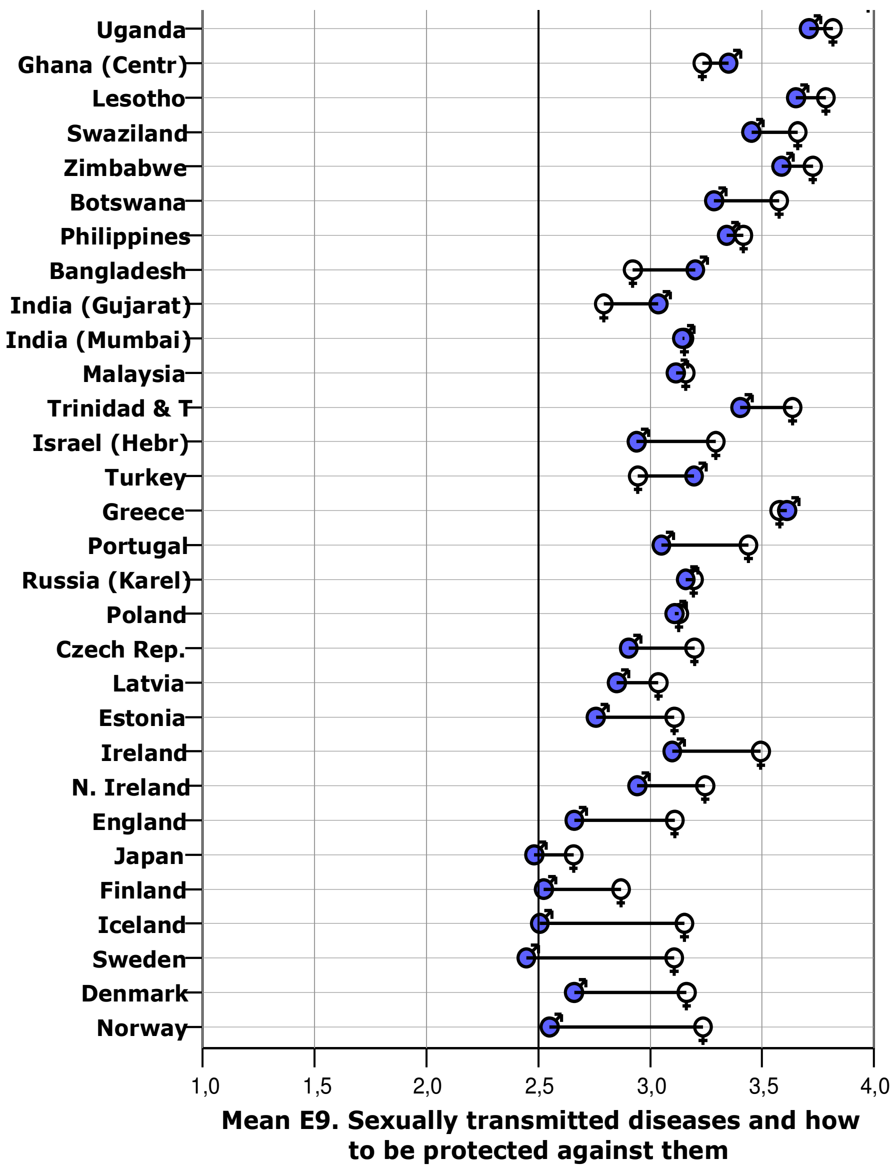


Figure 4-3 International comparison of responses to item E9

The interests of boys and girls are quite similar with both sexes selecting the same seven out of ten most popular items in Section E. In the least popular items, boys and girls overlap in seven out ten items. The most popular items for girls seem to suggest an interest in issues that have to do with personal health, beauty, reproductive behaviour and caring for the welfare of other people. Boys also have interest in reproductive health issues; they seem to show a marked interest in technical issues. Considering that in the twenty selected items, boys and girls overlap in fourteen out of twenty it can be regarded that they show fairly equal interests in the things they want to learn about.

In the top ten issues of interest (What I would like to learn about) there are some issues which are common to boys and girls. The mean values of the interests are nearly equal. Common interests are found in the Zimbabwe sample more than in European samples.

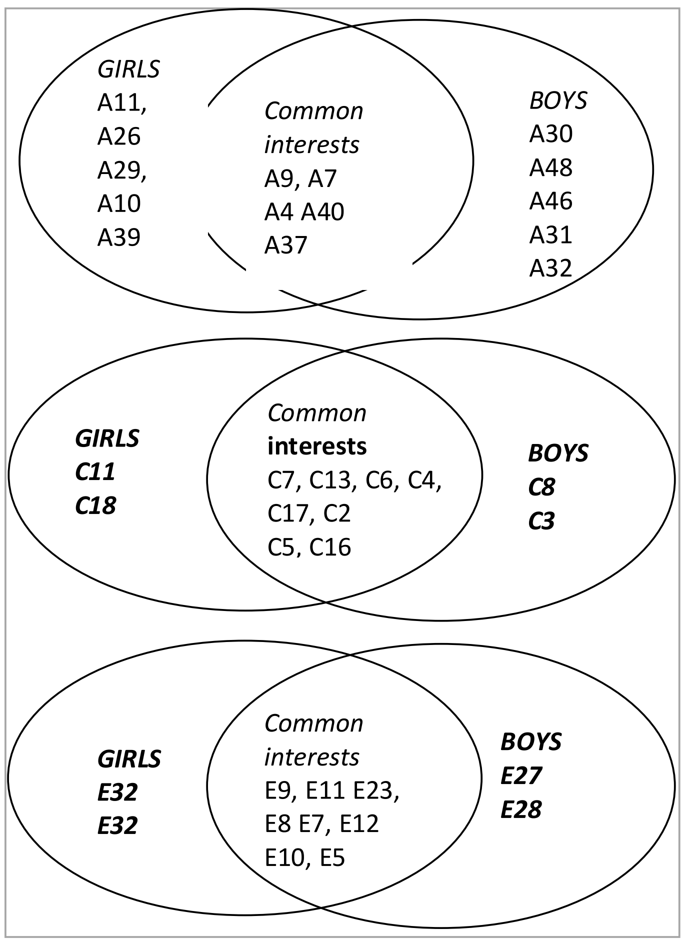


Figure 4-4 Common interests between boys and girls in the Zimbabwe sample

A high level of common interests between boys and girls is important for deciding what the science curriculum needs to engage the learners fully. **Figure 4-4** enables curriculum planning to include the learner as a stakeholder in the science education enterprise. Common interests are more likely to foster more collaboration than promote contrasting character between boys and girls. Natural commonalities that exist in learners, such as curiosity about the environment, aspirations and pressures from their societies can be explored in the curriculum to effect a more collaborative gender balance than foster their differences.

4.2.4 Distinct gender differences in Sections A, C and E

Table 4-10 summarises the interests where boys' choices are significantly different from girls in the Zimbabwe sample. Boys seem to be more interested in physical activity which they meet in daily life or see in movies and television. Their interests are about satisfying their curiosity. Whereas girls' choices can be grouped into beauty, care about people and other-worldly inclinations.

Table 4-10 Summary of the observed frequent interests in Sections A, C, E.

Significant boys interest	Significant girls interest
Curiosity, finding out	A36. How the eye can see light and colours
A30 How the atom bomb functions	**Beauty and health care**
A31. Explosive chemicals	A37. What to eat to keep healthy and fit
A44. Rockets, satellites and space travel	A39. The ability of lotions and creams to keep the skin young
A45. The use of satellites for communication and other purposes	A41. Plastic surgery and cosmetic surgery
A47. How petrol and diesel engines work	A42. How radiation from solariums and the sun might affect the skin
A48. How a nuclear power plant functions	**Caring for people**
C1. How crude oil is converted to other materials like plastics and textiles	A7. How the human body is built and functions
C2. Optical instruments and how they work	A8. Heredity, and how genes influence how we develop
C3. The use of lasers for technical purposes (CD-players, bar code readers, etc.)	A10. Birth control and contraception
C4. How cassette tapes, CDs and DVDs store and play sound and music	A11. How babies grow and mature
C5. How systems like radios and televisions work	A18. How radioactivity affects the human body
C7. How computers work	A26. Epidemics and diseases causing large losses of life
C14. Ghosts and witches, and whether they may exist	A38. Eating disorders like anorexia or bulimia
C15. Thought transference, mind-reading and whether they may exist	E7. How to control epidemics and diseases
C16. Why the stars twinkle and the sky is blue	E8. Cancer, what we know and how we can treat it
C17. Why we see the rainbow	E9. Sexually transmitted diseases and how to be protected against them
E27. Electricity, how it is produced and used in the home	E10. How to perform first-aid and use basic medical equipment
E28. How to use and repair everyday electrical and mechanical equipment	E11. What we know about HIV/AIDS and how to control it
E30. How electricity has affected the development of our society	E12. How alcohol and tobacco might affect the body
E41. Very recent inventions and discoveries in science and technology	E13. How different narcotics might affect the body
E42. Phenomena that scientists still cannot explain	E31. Biological and human aspects of abortion
	E35. Risks and benefits of food additives
	E23. How my body grows and matures
	E32. How gene technology can prevent diseases
	Concern for cost of living and environment
	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
	E26. Detergents, soaps and how they work
	Other-worldly
	A1. Stars, planets and the universe
	C9. Astrology and horoscopes, and whether the planets can influence human beings
	C12. Alternative therapies and how effective they are
	C11. Life and death and the human soul
	C13. Why we dream while we are sleeping, and what the dreams may mean

International Trends

In order to put Zimbabwe in an international context, ROSE data was pooled along with other participating countries. The cross section between developing and developed countries can be compared to see what trends exist and what they could mean. The countries were ordered according to the Human Development Index rankings of 2003-2004 when the data was collected. International trends also help to position Zimbabwe alongside countries of comparable histories and experiences with science education and science and technology. The accuracy of the comparisons cannot be guaranteed beyond the reliability of data collected for the human development indicators. The drop-line graphs show the reason why it is important to compare boys and girls. While the comparison does not show large gender differences in the Zimbabwe sample, the international does pool show large gender differences.

4.2.5 Human Development Index Rankings (2004)

The Human development index (HDI) is a summary measure of human achievement in three fundamental dimensions:

- Length of life expected at birth- a quality which depends on nutrition, quality of the health delivery system in the country among other things.
- Adult literacy rate and the primary, secondary and tertiary gross enrolment ratio.
- A decent standard of living measured by an individual's annual income.

The Capabilities Approach is based on the thinking that people are able to develop on the basis of what they can do. This places education and acquisition of skills at the forefront of all measurements of human achievement. The education index is a measure that also summarises different qualities of the education system and hence the basis for capabilities.

There are several competing variables that determine the interests and hence capabilities of children. Selected indicators may be good measures of the government priorities in different countries which influence development opportunities.

Table 4-11 Development indicators for 27 of the countries in the ROSE study.

Country	HDI rank	Life expectancy at birth (yrs.)	Public expenditure as % of GDP on			Education index	Researchers in R&D
			Education (1999-2001)	Military (2002)	Health (2001)		
Norway	1	78.9	6.8	2.1	6.8	0.99	4377
Sweden	2	80	7.6	2.6	7.4	0.99	5186
Iceland	7	79.7	6.0	0.0	7.6	0.96	6639
Japan	9	81.5	3.6	1.0	7.6	0.94	5321
Ireland	10	76.9	4.3	0.7	4.9	0.96	2190
England	12	78.1	4.6	2.4	6.3	0.99	2666
Finland	13	77.9	6.3	1.2	5.3	0.99	7110
Denmark	17	76.6	8.3	1.6	7.0	0.98	3476
Israel	22	79.1	7.3	2.1	6.0	0.94	1563
Greece	24	78.2	3.8	4.3	5.3	0.95	1400
Portugal	26	76.1	5.8	2.1	6.3	0.97	1754
Czech Rep	32	75.3	4.4	2.1	6.7	0.93	1466
Estonia	36	71.6	7.4	1.9	4.3	0.98	1947
Poland	37	73.8	5.4	1.9	4.6	0.96	1473
Latvia	50	70.9	5.9	1.8	3.4	0.95	1078
Trinidad	54	71.4	4.0		3.2	0.87	456
Russia	57	66.7	3.1	4.0	3.7	0.95	3494
Malaysia	59	73	7.9	2.4	2.0	0.83	160
Philippines	83	69.8	3.2	1.0	1.5	0.89	156
India	127	63.7	4.1	2.3	0.9	0.59	157
Botswana	128	41.4	2.1	4.0	4.4	0.76	
Ghana	131	57.8	4.1	0.6	2.8	0.65	
Swaziland	137	35.7	5.5	2.3	“	0.74	
Bangladesh	138	61.1	2.3	2.5	1.5	0.45	51
Lesotho	145	36.3	10.0	2.7	4.3	0.76	
Uganda	146	45.7	2.5	2.4	3.4	0.70	24
Zimbabwe	147	33.9	10.4	2.7	3.4	0.79	

Source: Human Development Index Report 2004

Trends from published development indicators show interesting patterns from the high income to low income countries. Three distinct economic levels emerge based on life expectancy:

- Group 1 countries: HDI rank 1-40. This range groups more participants from the OECD countries, with high incomes, high expenditure on R&D, health and education and very high life expectancies.

- Group 2 countries: HDI range 41-100. Overlapping with high income countries but with lower investment in R&D, health and education. Some may have high levels of development in basic research but when all the elements of HDI are considered, their ranking is lower than group 1.

- Group 3 countries: HDI range greater than 100. Very low life expectancy for some. Generally low income and much lower expenditure on R&D, education and health. Some tend to have higher military spending than education and health (India, Bangladesh).

- Higher proportion of GDP (10.4) was spent in Zimbabwe on education than other developing countries.

- Drop-line graphs of Sections A, C, E show that children in higher income countries with more investment in science and technology research (HDI 2004) show lower interest in learning science and technology.

- Children in developing countries have higher interests in almost all science topics than children in developed countries.

Zimbabwe had the highest expenditure of the national income on education (10.4%), and R&D yield benefits such as higher income, higher literacy and health. High income countries actually show a positive correlation between their HDI and investment in R&D and their health delivery systems. Regrettably some countries make bigger military budgets than health and education such as Russia (3.1% education, 4.0% military, 3.7% health), Botswana (4, 0% education, 4.4% military, 3.7% health) (HDI 2004).

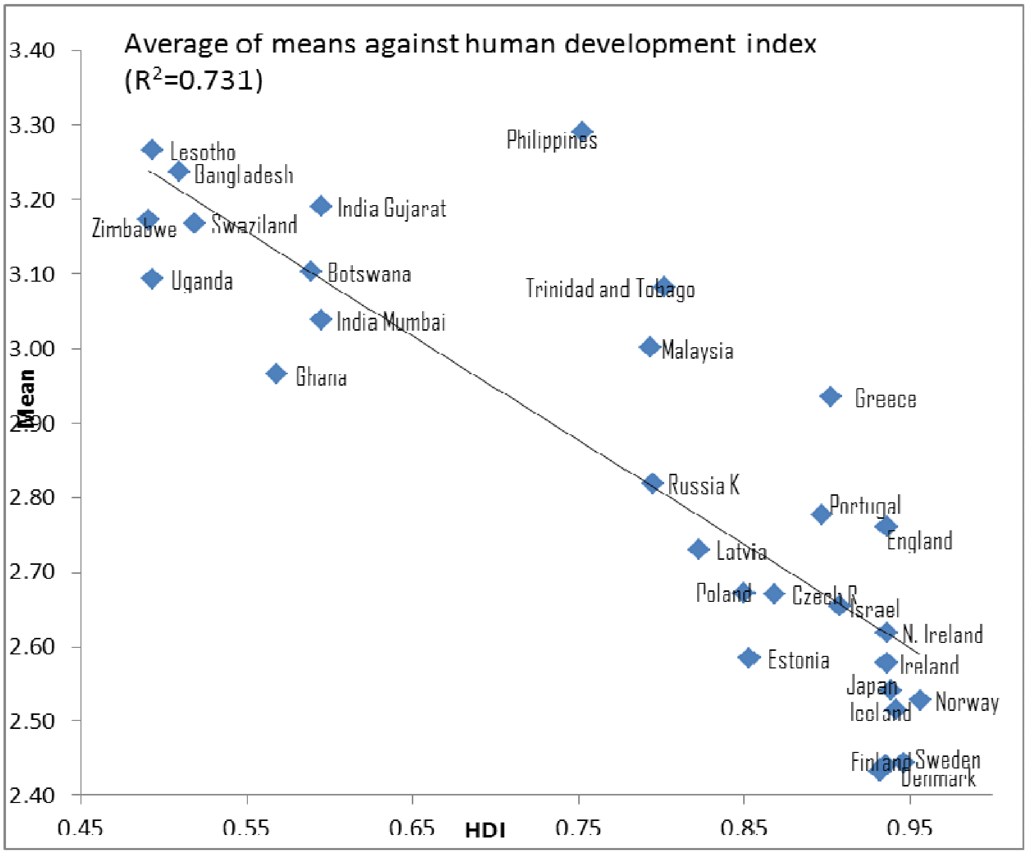


Figure 4-5 Means of interests from A, C, E (y axis) plotted against Human development index.

High interest in science is generally found in less developed countries than the rich countries.

Low income countries such as Zimbabwe have very low GDP and little of research but it is the learners in developing countries that express high interest in learning about science. The data was collected in all countries in the same period (2003-4). A pattern emerges with the high income countries showing very low interest in learning science.

Figure 4-6 shows per capita electricity consumption. It is seems children who have very little everyday use of electricity tend to wish they could have it more, whereas those who have more resources perhaps take it as normal and do not actively express interest in it.

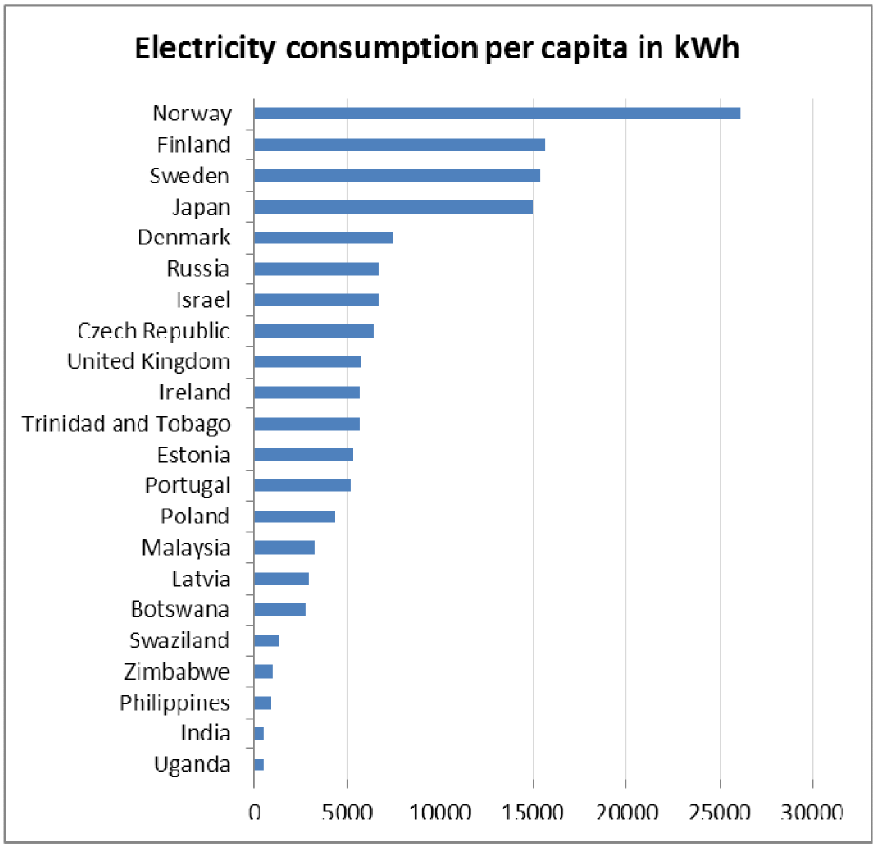


Figure 4-6 Per-capita electricity (kWh) consumption in 27 of the ROSE countries

4.2.6 Factor analysis of items on 'What I want to learn about'

Twelve factors emerged from the factor analysis of A, C and E items from Zimbabwe. Factor analysis (SPSS) generated the Principal component matrix of the factors that emerged from an extraction with Direct Oblimin rotation. Reliability analysis of the factors that hang together was done to test the extent to which the items truly reflect the underlying construct. Cronbach's- α (range 0-1) for all the composite factors was found within an acceptable range for attitudinal items. An acceptable range for Cronbach's-α for attitudinal factors is from 0.5 to 1.0, according to Roberts and Clifton, (1992). Factor analysis reduced the number of items one had to deal as shown in Table 4-12*Figure 4-7*

Table 4-13 Factor summary for Sections A, C and E 'What I want to learn about'

Factor summary	Component items	Cronbach's α
1 Atoms and energy	A30. How the atom bomb functions A31. Explosive chemicals A48. How a nuclear power plant functions A47. How petrol and diesel engines work A17. Atoms and molecules A32. Biological and chemical weapons and what they do to the human body A2. Chemicals, their properties and how they react	0.755
2 Earth Phenomena	A24. Earthquakes and volcanoes A4. How mountains, rivers and oceans develop and change A5. Clouds, rain and the weather A3. The inside of the earth A25. Tornados, hurricanes and cyclones	0.703
3 Reproductive biology	A10. Birth control and contraception A9. Sex and reproduction A11. How babies grow and mature A7. How the human body is built and functions A15. How plants grow and reproduce	0.679
4 Radiation & the human body	A43. How the ear can hear different sounds A36. How the eye can see light and colours A46. How X-rays, ultrasound, etc. are used in medicine A42. How radiation from solariums and the sun might affect the skin	0.661
5 Health and fitness	A40. How to exercise to keep the body fit and strong A37. What to eat to keep healthy and fit A41. Plastic surgery and cosmetic surgery A39. The ability of lotions and creams to keep the skin young A38. Eating disorders like anorexia or bulimia	0.613
6 Information technology	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 C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.) C2. Optical instruments and how they work (telescope, camera, microscope, etc.) C7. How computers work	0.798
7 Spirit and extrasensory perception	C14. Ghosts and witches, and whether they may exist C15. Thought transference, mind-reading, sixth sense, intuition, etc. C11. Life and death and the human soul C13. Why we dream while we are sleeping, and what the dreams may mean	0.741
8 Control of diseases	E11. What we know about HIV/AIDS and how to control it E9. Sexually transmitted diseases and how to be protected against them E12. How alcohol and tobacco might affect the body E10. How to perform first-aid and use basic medical equipment E7. How to control epidemics and diseases E13. How different narcotics may affect the body E8. Cancer, what we know and how we can treat it	0.792
9 Energy in everyday life	E28. How to use and repair everyday electrical and mechanical equipment	0.722

		E27. Electricity, how it is produced and used in the home E30. How electricity has affected the development of our society 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.	
10	Science and knowledge	E41. Very recent inventions and discoveries in science and technology E40. Inventions and discoveries that have changed the world E42. Phenomena that scientists still cannot explain E38. Big blunders and mistakes in research and inventions	0.730
11	Responsibility for the environment	E3. The ozone layer and how it may be affected by humans E5. What can be done to ensure clean air and safe drinking water E4. The greenhouse effect and how it may be changed by humans E6. How technology helps us to handle waste, garbage and sewage	0.660
12	Space science	A35. How to find my way and navigate by the stars A34. How it feels to be weightless in space A1. Stars, planets and the universe A44. Rockets, satellites and space travel	0.671

4.2.7 Factor 1.1 Atoms and energy

Table 4-14 Items in Factor 'Atoms and energy' from Zimbabwe

A30. How the atom bomb functions	
A31. Explosive chemicals	***Cronbach's Alpha***
A48. How a nuclear power plant functions	***0.755***
A47. How petrol and diesel engines work	
A17. Atoms and molecules	
A32. Biological and chemical weapons and what they do to the human body	
A2. Chemicals, their properties and how they react	

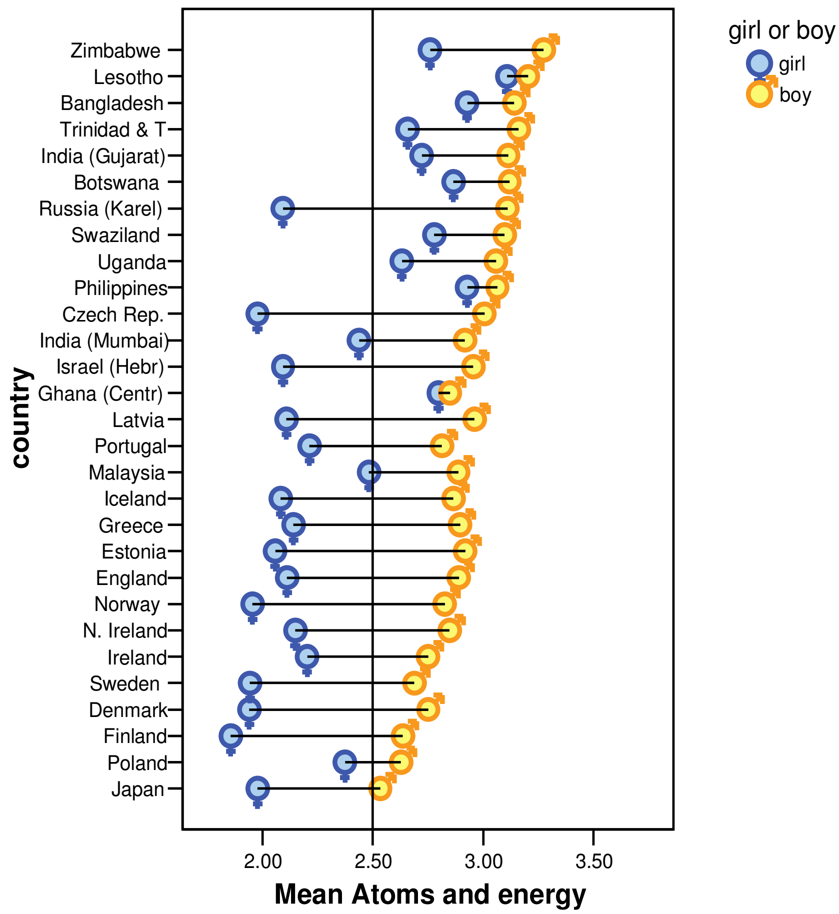


Figure 4-7 International comparison of means of factor 'Atoms and Energy'

Interest in energy released from atoms and chemicals is quite high for children in the low income countries. Items factor out with a high internal consistency (α=0.755). Though the loading on item A2 is rather low, it still makes a very logical combination with the other items. Children develop interest in these issues through exposure in school and other everyday sources. On the international scale the same composite factor is investigated for other countries that participated in the ROSE study. Generally all boys are more interested in learning about energy from chemicals and atoms than girls. In many countries the gender difference is quite large.

All the seven items making up this composite factor are centred on the energy associated with atoms which is used for military purposes. Both boys and girls in Zimbabwe expressed interest in learning about these issues along with respondents from other low income countries. The children may not clearly have understood the actual mechanisms of atomic energy, chemical explosives or biological weapons but a common thread in all the items is the explosive nature of certain substances. Item A2 may not directly allude to weapons, it can be regarded that at age 16, children know that weapons are based on the chemical and atomic energy.

4.2.8 Factor 1.2 Earth Phenomena

Table 4-15 Zimbabwe items composing the factor 'Earth Phenomena'

A24. Earthquakes and volcanoes A4. How mountains, rivers and oceans develop and change A5. Clouds, rain and the weather A3. The inside of the earth A25. Tornados, hurricanes and cyclones	Cronbach's Alpha= 0.703

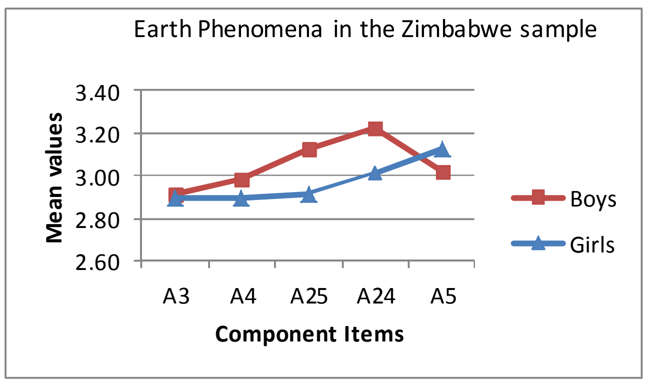
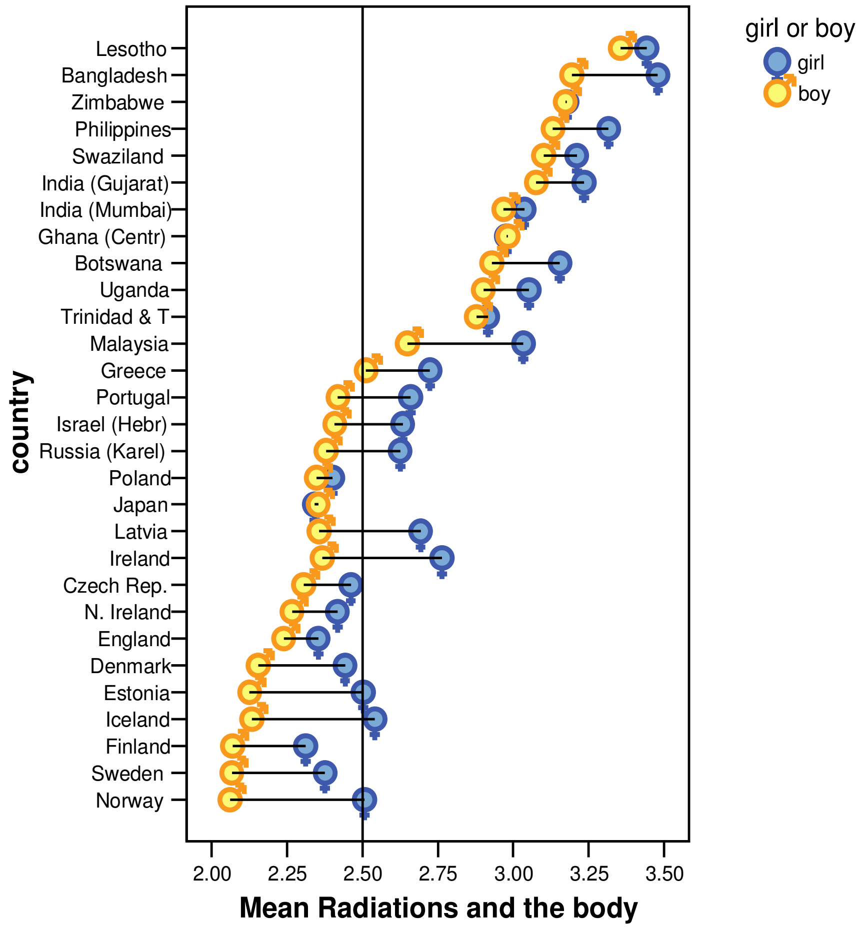


Figure 4-8 "Earth Phenomena" in Zimbabwe

The scale in Figure 4-8 has been deliberately edited to include only the effective range because the means for boys and girls are very close. There are far less frequent natural disasters of this nature in Zimbabwe, but children still show a high level of interest.

Factor loadings are in the intermediate range with a high Cronbach-α value. It is quite logical to have these items factor out together and be of interest to 16 year olds. Children have questions about these phenomena and even though they are not all covered in school science; other areas of the curriculum such as geography are able to satisfy their desire to learn about these things.



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Girls tend to have a higher interest in issues that have to do with radiations and the body. Many boys in the OECD and Asian countries are far less interested. The interest of boys in developing countries is less easy to interpret, besides assuming that girls at this age are getting more conscious of their bodies and so they are more likely to want to learn about it. Learners in Zimbabwe were very interested in learning about radiation.

4.2.11 Factor 1.5 Health and fitness

Table 4-18 Items making up the 'Health and Fitness' factor

A40. How to exercise to keep the body fit and strong	Cronbach's
A37. What to eat to keep healthy and fit	Alpha
A41. Plastic surgery and cosmetic surgery	=0.613
A39. The ability of lotions and creams to keep the skin young	
A38. Eating disorders like anorexia or bulimia	

Girls are much more interested in health awareness than boys and low income countries are much more decided about it. While both sexes are interested, girls are more so than boys in many countries.

The concept of health and fitness seems to be popular in the Zimbabwe sample. Girls are much more enthusiastic than boys especially with Item 39 which is about keeping the skin looking young. It can explain the sharp peak for girls at this point and for the fitness factor in general.

4.2.12 Factor 1.6 Information technology use

Table 4-19 Zimbabwe items making up the 'Information technology use' factor

C4. How cassette tapes, CDs and DVDs store and play sound and music	Cronbach's
C5. How things like radios and televisions work	Alpha
C6. How mobile phones can send and receive messages	0.816
C3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	
C2. Optical instruments and how they work (telescope, camera, microscope, etc.)	
C7. How computers work	

In the Information technology factor, boys tend to be much more interested even in developed countries that are generally disinterested. While both boys and girls are equally interested in Philippines and Malaysia, generally girls are trailing behind boys in information technology factors. Internet use in Zimbabwe is estimated at 13% (HDI 2005). Cost of the technology is a likely reason why IT use is low. However with increasing availability of mobile phones and more diverse services, the percentage use of IT is set to increase. The high level of interest is a good guarantee that IT use will increase.

4.2.13 Factor 1.7 Spirit and extrasensory perception

Table 4-20 Items making up 'Spirit and extrasensory perception' factor

C14. Ghosts and witches, and whether they may exist	Cronbach's
C15. Thought transference, mind-reading, sixth sense, intuition, etc.	Alpha=
C11. Life and death and the human soul	0.631
C13. Why we dream while we are sleeping, and what the dreams may mean	

Girls in all the sampled countries showed a great interest in issues coined 'Spirit and Extrasensory perception'. Learners in most countries were interested except a small number of boys in developed countries who were not interested. In all other countries, girls were far more interested than boys.

4.2.14 Factor 1.8 Control of Disease

Table *4-21* Items making up 'Control of Disease' factor

E11. What we know about HIV/AIDS and how to control it E9. Sexually transmitted diseases and how to be protected against them E12. How alcohol and tobacco might affect the body E10. How to perform first-aid and use basic medical equipment E7. How to control epidemics and diseases	Cronbach's Alpha= 0.750

All learners who participated could be safely deemed to be interested in control of disease as a normal behaviour in everyday life. Closer analysis in the Zimbabwe sample showed that girls had a higher mean in all components of the factor but boys were also very interested in the issue. This factor ties in very well with the ideas shown in response to item I – what they would research on if they had the opportunity.

4.2.15 Factor 1.9 Energy in everyday life

Table 4-22 Items making up the factor 'Energy in everyday life'

E28. How to use and repair everyday electrical and mechanical equipment E27. Electricity, how it is produced and used in the home E30. How electricity has affected the development of our society 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**.**	Cronbach's Alpha=0.777

Awareness of the use of energy in everyday life situations is quite high in the Zimbabwe respondents. Boys were more interested in items that had to do with energy in everyday life. The international comparison was well reproduced in the Zimbabwe sample. Even if girls are also very interested it would explain a lot about the apparent elevated interest shown by boys.

4.2.16 Factor 1.10 Science and knowledge

Table 4-23 Items constituting factor 'Science and knowledge'

E41. Very recent inventions and discoveries in science and technology E40. Inventions and discoveries that have changed the world E42. Phenomena that scientists still cannot explain	Crobach's Alpha 0.690

Again boys in the international and Zimbabwe samples tend to lead the girls in the factor Science and knowledge. Only a few countries showed a low level of interest especially in the developed countries.

4.2.17 Factor 1.11Environmental Responsibilities

Table 4-24 Items making up 'Environmental responsibility' factor

E3. The ozone layer and how it may be affected by humans	Cronbach's
E5. What can be done to ensure clean air and safe drinking water	Alpha=
E4. The greenhouse effect and how it may be changed by humans	0.660
E6. How technology helps us to handle waste, garbage and sewage	

Countries that tend to depend on the ecology of the land such as the African countries have an equally shared conviction on the factor. In other countries, girls are in the lead and learners in some rich countries do not seem interested in environmental responsibility issues. The data does not say why and also we cannot deduce whether the lack of interest is because they hear the same message often or that their environments are protected by strict laws to which learners have taken as natural. It is interesting to note that Green Parties are more European than African or Asian yet the children in Africa and Asia show more interest in issues of Environmental responsibility.

4.2.18 Factor 12 Space science

Table 4-25 Items that constitute the factor 'Space Science'

A35. How to find my way and navigate by the stars	Cronbach's
A34. How it feels to be weightless in space	Alpha=
A1. Stars, planets and the universe	0,653
A44. Rockets, satellites and space travel	

Apparently space science is highly regarded by both boys and girls in the Zimbabwean schools. The same attitude towards space science is found in developed countries and other developing countries. Boys however show a higher margin of interest than girls. While it is not possible to do space science practically in most countries, interest still is quite significant. The knowledge generated by those countries that actually send space-craft keeps learners across borders to remain interested in this branch of science.

4.3 Research question 2: What attitudes do learners develop from science class experiences?

Pupils' views of their actual experiences in science classes are critical to understanding the basis of their interests and especially to establish meaning for the patterns of interests shown. All the factors in this section point to a positive attitude towards science. From the high interests shown in sections A, C and E, it would be expected that positive factors would emerge. Section F of the ROSE questionnaire has 16 items that asked students to reflect on their experiences in their science classes. Factor analysis was used to reduce the items into composite variables where the items are grouped by common underlying structures.

Table 4-26 shows the four composite variables that emerged from factor analysis. The same configuration of factor analysis is used throughout this study: Principal component extraction with Direct Oblimin rotation. All the emergent factors are about children embracing a culture of scientific thought.

Table 4-26 Composite variables from factor analysis of items on 'My science classes'

Construct	Constituent Items making up construct	Cronbach's α
Factor 1 Interest in science	F2. School science is interesting F3. School science is rather easy for me to learn F4. School science has opened my eyes to new and exciting jobs	0.702
Factor 2 Valuing science	F4. School science has opened my eyes to new and exciting jobs F14. I would like to become a scientist F16. I would like to get a job in technology F15. I would like to have as much science as possible at school F5. I like school science better than most other subjects F9. School science has made me more critical and sceptical	0.799
Factor 3 Positive influences of science education	F12. School science has shown me the importance of science for our way of living F13. School science has taught me how to take better care of my health F7. The things that I learn in science at school will be helpful in my everyday life F8. I think that the science I learn at school will improve my career chances F10. School science has increased my curiosity about things we cannot yet explain F6. I think everybody should learn science at school F4. School science has opened my eyes to new and exciting jobs	**0.807**
Factor 4 Science as a way of life	F11. School science has increased my appreciation of nature F12. School science has shown me the importance of science for our way of living F13. School science has taught me how to take better care of my health	0.646

4.3.1 Factor 2.1 Interest in science

Items F2, F3 and F4 factor out together with high item reliability, Cronbach alpha value of 0.72. The items are combined into a new composite variable called 'Interest in science classes'. As a new variable, SPSS enables computation of mean values for all cases from the constituent items. The mean values can take more than the 4 Likert points but still remain within the same range from 1 to 4. **Table 4-27** summarises the interest expressed by students as calculated from the new composite variable.

It is interesting to note that the same interest shown by learners in Zimbabwe is not shared by learners from different countries. Youths in developed countries are generally less interested in science classes than Zimbabwe and other developing countries. For all items all youths are interested but the level shown in the developed countries is rather low.

Table 4-27 Zimbabwe frequencies of responses to factor 'Interest in Science'

Item	Disagree	lo disagree	lo agree	Agree	Mean	Std. Error	Std. Deviation	Variance
F2. School science is interesting	172	79	145	314	3.37	.039	1.044	1.090
F3. School science is rather easy for me to learn	113	60	103	433	2.85	.046	1.225	1.501
F4. School science has opened my eyes to new and exciting jobs	90	35	108	481	3.21	.043	1.137	1.292

4.3.2 Factor 2.2: Valuing Science

Table 4-28 Zimbabwe items that make up the factor 'Valuing Science'

Love for science. Wish for a career in science	F4. School science has opened my eyes to new and exciting jobs F14. I would like to become a scientist F16. I would like to get a job in technology F15. I would like to have as much science as possible at school F5. I like school science better than most other subjects F9. School science has made me more critical and sceptical	Cronbach's Alpha **0.799**

'Valuing science' is a label attached to the composite variable formed from the factoring of items f4, f14, f16, f15, f5 and f9. Reliability analysis gives Cronbach's alpha value of 0.799 for this construct. The highest number of respondents had means between value labels 3 and 4 (low agree and Agree) indicating a very strong interest level. The reasons for this interest cannot be identified from this variable alone but it is a result of several factors which are not considered here. More than half the pupils tend to regard science as a very important subject. There are also a rather large number of learners who actually do not agree to any value in science.

Mean responses above 2.5 were indicating agreement that there is value in science. The number of students who attached value to science classes is much higher than those who did not see it as important.

4.3.3 Independent samples t-test for factor 'Valuing science'

Table 4-29 Independent samples test for factor 2.2 to contrast boys and girls in Zimbabwe.

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
f04	4.609	**.032**	-1.362	705	**.174**	-.117	.086	-.286	.052
f05	19.680	**.000**	-3.518	700	**.000**	-.324	.092	-.505	-.143
f09	18.805	**.000**	-2.629	679	**.009**	-.243	.092	-.425	-.062
f14	11.949	**.001**	-2.384	704	**.017**	-.222	.093	-.405	-.039
f15	17.610	**.000**	-2.835	704	**.005**	-.241	.085	-.409	-.074
f16	30.869	**.000**	-4.155	705	**.000**	-.361	.087	-.531	-.190

Despite equal treatment (science education experiences) it was important to test the significance of the gender related attitude differences. From the t-test, the Levene's test for equality of variances showed that the significance value is less that .5 and so equal variance between boys and girls was not assumed. For all constituent items there is a strong significance (2-tailed) in the attitude across gender (highlighted).

International comparison is made in two of the constituent items in order to emphasise the constituent items in the construct *'Valuing science', F6* 'I would like to get a job in technology' *and F5 'I like school science better than other subjects'*. Boys in the African countries, Philippines, Malaysia and Trinidad show a higher response than girls for 'Valuing science' but overall, both sexes in these countries are higher than the more developed countries. Youths in the same countries also show high interest in school science than youths in countries like Japan, the Nordic countries, England and Ireland and the East European bloc.

4.3.4 Factor 2.3: Positive influence of science education

Factor analysis groups seven items in this variable. Their reliability analysis gives a Cronbach value 0.807 implying a very high degree of consistency. **Table 4-30** shows the constituent items of the variable 'Positive influence of science education'.

Table 4-30 Constituent items of the variable 'Positive influence of science education' in Zimbabwe

Factor 3	F12. School science has shown me the importance of science for our way of living	Cronbach alpha 0.807
Positive influences of science education	F13. School science has taught me how to take better care of my health	
	F7. The things that I learn in science at school will be helpful in my everyday life	
	F8. I think that the science I learn at school will improve my career chances	
	F10. School science has increased my curiosity about things we cannot yet explain	
	F6. I think everybody should learn science at school	
	F4. School science has opened my eyes to new and exciting jobs	

Frequency plot of the composite variable '*Positive influence of science education*' shows a very high response within the Zimbabwean sample. An alpha value of 0.807 shows a high consistency of these items in the sample indicating a strong co-variance with the positive influences of science education. However the test for the equality of means shows that the 2-tailed significance values are very large. For the seven items only F12 has a significance difference, otherwise for the rest significance values range from .6 to .9 which suggests no significant difference.

4.3.5 Factor 2.4: Science as a way of Life

The last composite variable from experiences in science classes is summarised 'Science as a way of Life'. **Table 4-31** shows its constituent items.

Table 4-31 Zimbabwe items that constitute the factor 'Science and a way of Life'

Factor 4	F11. School science has increased my appreciation of nature	Cronbach alpha 0.646
Science as a way of life	F12. School science has shown me the importance of science for our way of living	
	F13. School science has taught me how to take better care of my health	

Table 4-32 Group statistics from independent-samples t-test 'Science as a way of life'

Item	sex	N	Mean	Std. Deviation	Std. Error Mean
f11	girl	379	3.25	1.119	.057
	boy	320	3.29	.998	.056
f12	girl	388	3.37	1.057	.054
	boy	319	3.38	1.008	.056
f13	girl	385	3.53	.944	.048
	boy	321	3.40	.995	.056

Items F11 and F12 do not show significant differences (S= 0.62 df=697, SD=and S= 0.949, df=705). There are no differences because most respondents are all very positive.

Table 4-33 Independent samples t-test (Zimbabwe data)

Item		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean	Std. Error
F11	Equal var. not assumed	7.463	**.006**	-.494	697	**.621**	-.040	.081
F12	Equal var. not assumed	.834	**.361**	-.064	705	**.949**	-.005	.078
F13	Equal var. not assumed	5.501	**.019**	1.872	704	**.062**	.137	.073

4.4 Research question 3: How do out-of-school experiences influence pupils' opinions about science and technology?

Actual experiences out of school are an indication of the things that children learn practically and can use to define the quality of their lives. Everyday activities reflect the cultural and social profiles of different people. Sixty one different items in this section present a wide range of activities that young people can be expected to get involved with in different parts of the world. The items are factor analysed to reduce them to a small number of composite variable which are grouped by some underlying construct. For each factor, the response frequency is plotted in the sampled population. The factors are then cross-tabulated with items relating to opinions about science and technology.

4.4.1 *Factor 3.1: Interaction and communication with electronic information*

Seven items grouped together in factor analysis and form one variable associated with handling of digital information.

Table 4-34 Interaction and communication using electronic information

H49. downloaded music from the internet	Cronbach α
H50. sent or received e-mail	0.816
H51. used a word processor on the computer	
H46. searched the internet for information	
H47. played computer games	
H48. used a dictionary, encyclopaedia, etc. on a computer	
H45. sent or received an SMS (text message on mobile phone)	

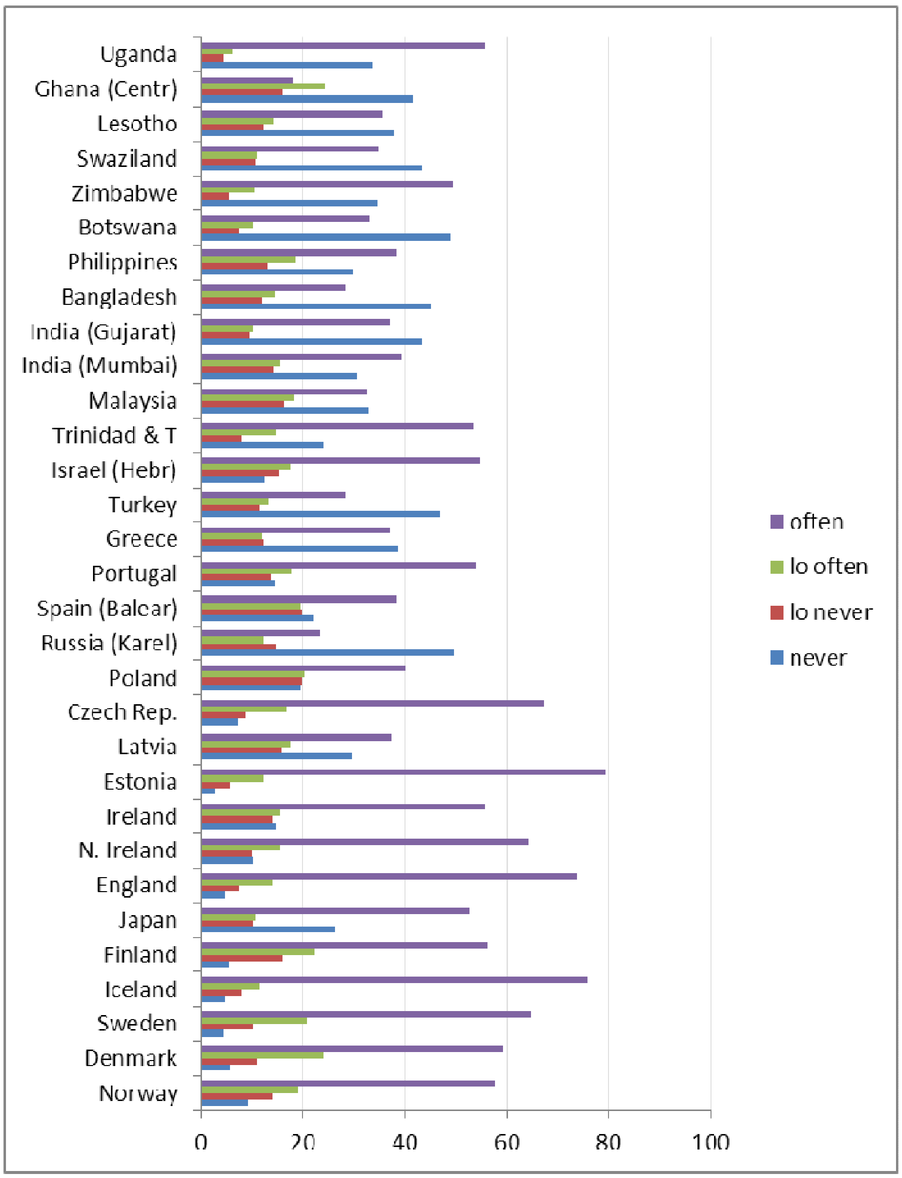
Within the sampled Zimbabwean population the overall mean (2.8) for the interaction with electronic information is very low and indicates infrequency in the use of information technology. A Cronbach's alpha value of 0.816 confirms a high degree of reliability of the factoring of the items.

Table 4-35 *Frequencies of the items on Interaction with electronic information (Zimbabwe)*

Item	Response Category				Mean	Std. Error of Mean	S.D	Variance
	1	2	3	4				
H44. used a mobile phone	110	48	88	440	3.25	.043	1.137	1.292
H45. sent or received an SMS (text message on mobile phone)	225	47	79	333	2.76	.052	1.348	1.817
H46. searched the internet for information	231	51	85	315	2.71	.052	1.345	1.810
H47. played computer games	145	46	95	402	3.10	.046	1.219	1.487
H48. used a dictionary, encyclopaedia, etc. on a computer	143	44	62	433	3.15	.047	1.232	1.518
H49. downloaded music from the internet	294	47	72	274	2.47	.053	1.380	1.906
H50. sent or received e-mail	238	37	72	339	2.75	.052	1.369	1.874
H51. used a word processor on the computer	234	52	77	320	2.71	.052	1.354	1.832

At least 50% of all respondents have had interaction with electronic information, especially word processing, games and information search. Interaction with information technology depends on availability of the physical equipment, functional networking and human skills to teach and manage the information technology as a system. Developed countries have more facilities enabling interaction with electronic information than Zimbabwe. However, do the youths in the developed world have a different level of interaction? It is interesting to note that Uganda has an exceptionally high frequency compared to other African countries. There has been significant government investment into information technology in schools which could be the reason why there is more interaction. Access to high speed internet is now possible through the SEACOM high speed link that was laid in the Indian Ocean in 2010. This is ahead several African countries which still have to get connected.

Table 4-36 Country comparison of frequency of interaction with electronic information



4.4.2 *Factor 3.2: Mechanization of labour*

Table 4-37 Items making up factor 'Mechanisation of labour'

H58. used a rope and pulley for lifting heavy things	**Cronbach alpha**
H57. used a crowbar (jemmy)	**0.685**
H59. mended a bicycle tube	
H56. used a wheelbarrow	
H61. charged a car battery	
H39. changed or fixed electric bulbs or fuses	**Cronbach alpha**
H40. Connected an electric lead to a plug etc.	**0.690**
H60. used tools like a saw, screwdriver or hammer	
H52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works	

Table 4-38 Responses to Factor 3.2 and dispersion in Zimbabwe sample

Items	Never	lo never	lo often	often	Std. Error	Std. Dev.	Var
H56. used a wheelbarrow	**53**	54	108	**461**	.036	.937	.878
H57. used a crowbar (jemmy)	**300**	85	82	**187**	.051	1.294	1.673
H58. used a rope and pulley for lifting heavy things	**213**	60	95	**308**	.051	1.318	1.738
H59. mended a bicycle tube	**275**	53	78	**268**	.053	1.365	1.864
H60. used tools like a saw, screwdriver or hammer	**101**	41	110	**423**	.042	1.103	1.217
H61. charged a car battery	**356**	41	49	**228**	.053	1.381	1.908
H52. opened a device (radio, watch, computer, telephone, to find out how it works	**177**	51	86	**378**	.049	1.282	1.644
H39. changed or fixed electric bulbs or fuses	**159**	66	84	**375**	.048	1.256	1.577
H40. connected an electric lead to a plug etc.	**155**	60	93	**374**	.048	1.244	1.548

The 'often' category has high numbers which indicates a fairly high level of practical application of simple skills. However the numbers of respondents who have never had practical experience with everyday mechanisation is also high. Practical involvement in these activities has two major outcomes for the children: a deeper understanding of the scientific principles involved and solving immediate problems. The overall outcome is an ability to apply these skills to other novel situations that may arise. It is a means of establishing a scientific literacy in the technological everyday lives of the learners.

4.4.3 Factor 3.3: Interaction with plants and animals

Table 4-39 Items constituting the factor 'Interaction with plants and animals'

H10. milked animals like cows, sheep or goats	**Cronbach**
H6. watched (not on TV) an animal being born	**alpha**
H7. cared for animals on a farm	**0.602**
H14. collected edible berries, fruits, mushrooms or plants	
H11. made dairy products like yoghurt, butter, cheese or ghee	

With more rural to urban migration and for the reason that more urban people participated in the study, the frequency of interaction with animals and plants is low. It would be expected that in Zimbabwe, children would have lots of experience with animals since it is a country with an agro-based economy. Figure 4-9 indicates a large percentage of children who have actually never had any contact with farm animals. Much as it is a farming country, reports seem to indicate that the trend is moving to mechanisation which removes dependence on animals. Animal husbandry is getting more large scale commercial and hence inaccessible to most children.

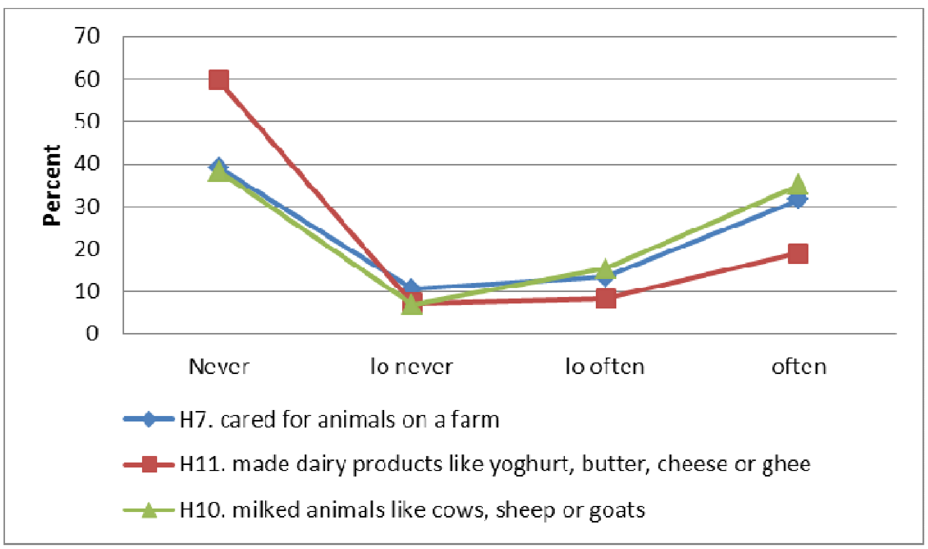


Figure 4-9 Experiences of Zimbabwe children with animals

Urbanisation and the depression of the economy could also explain that families sell away or kill their livestock for sustenance. The few children who report experiences in making dairy products could be either farm workers' children or farm owner's children. Generally it can be concluded that the sampled children have not learnt domestic dairy processing skills from living with animals. Such skills add value to life and form very useful background knowledge necessary for understanding biotechnological processes in food processing.

4.4.4 Factor 3.4: Outdoor activities

Table 4-40 Items making up 'Outdoor activities'

H16. participated in fishing	.Cronbach's
H15. participated in hunting	Alpha=0.629
H21. put up a tent or shelter	
H30. used binoculars	

In this factor, figures from the frequencies of individual items analysis are used to show deductions that can be made from the Zimbabwe sample. Putting up a tent and using binoculars are not common activities for most learners. That would explain why their figures from the iterations are not high. However fishing, making a fire, preparing food over a wood fire are all common experiences for most learners. A lot of learners are town dwelling and will not have had the experiences of camping, fishing and hunting. Even in the rural areas, these activities are dying away as easier means of living develop. The few experiences that remain are mainly done as a sport rather than a necessary means of living. Means are small and there is small variability in the sample because the dispersion is very little.

Table 4-41 Frequencies of the items in Factor 3.4

Item	Response Categories				Mean	Std. Error	Std. Deviation
	1	2	3	4			
H30. used binoculars	**165**	66	96	**385**	2.94	.048	1.258
H15. participated in hunting	**362**	53	85	**206**	2.19	.050	1.329
H16. participated in fishing	**248**	63	99	**293**	2.62	.050	1.333
H21. put up a tent or shelter	**259**	63	113	**255**	2.53	.050	1.320

4.4.5 Zimbabwean youth opinions about science and technology

Table 4-42 Items where students showed scepticism

Item	Response categories				Mean	Std. Error	Std. Dev.	Var.
	1	2	3	4				
G14. We should always trust what scientists have to say	**362**	89	96	**151**	2.05	.047	1.233	1.521
G10. Science and technology are the cause of the environmental problems	**309**	102	97	**187**	2.23	.048	1.268	1.608
G8. Science and technology can solve nearly all problems	**245**	104	124	**224**	2.47	.048	1.264	1.597
G9. Science and technology are helping the poor	**289**	100	112	**191**	2.30	.048	1.264	1.598

In these four items, the respondents were in disagreement and the means are all below 2.5. It is also noticed that it is in these items that missing responses were highest. It may be a strong indication that the *missing* values includes some attitudinal information and is not simply that they did not understand or want to answer the particular item. Higher frequencies in scepticism indicates a level of understanding of the limitations of science, despite the positive aspects if science and technology. Lack of dispersion in responses suggests a high number of common responses

Table 4-43 High opinions about science and technology in Zimbabwean youths

Items	Response categories				Mean	Std. Error	Std. Dev.	Var
	1	2	3	4				
G16. Scientific theories develop and change all the time	131	86	112	**372**	3.03	.045	1.184	1.402
G1. Science and technology are important for society	76	38	76	**521**	3.47	.037	.999	.998
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	119	49	135	**409**	3.17	.042	1.133	1.284
G3. Thanks to science and technology, there will be greater opportunities for future generations	62	56	116	**470**	3.41	.036	.965	.931
G4. Science and technology make our lives healthier, easier and more comfortable	74	57	137	**436**	3.33	.038	1.007	1.015
G5. New technologies will make work more interesting	69	55	123	**457**	3.38	.037	.990	.980
G6. The benefits of science are greater than the harmful effects it could have	156	74	148	**319**	2.90	.046	1.205	1.452
G7. Science and technology will help to eradicate poverty and famine in the world	199	98	126	**274**	2.68	.048	1.256	1.577
G11. A country needs science and technology to become developed	74	49	117	**459**	3.37	.038	1.006	1.011

Students had very high opinions of most of the items in this section. There is an indication of a sense of critical belief in science and technology. More respondents are positive about these views of science and technology. Items G1, G2 and G3 are showing that more than half the children are looking for solutions to the HIV and AIDS problem in science and technology. This is especially important in view of the many myths and misconceptions about the treatment of HIV and AIDS.

Items G1, G3, G4 and G5 in **Table 4-44** convey a mature understanding of the importance of science and technology for society and human development. Students understand the fact that science and technology comes at a price and decisions have to be made with due consideration of the benefits and deficits of science and technology. These youths are likely to develop into adults who can make informed and considered decisions about investing in science and technology development.

Table 4-44 Critical views about scientists

Items	Response Categories				Mean	Std. Error	Std. Dev.	Var
	1	2	3	4				
G16. Scientific theories develop and change all the time	131	86	112	372	3.03	.045	1.184	1.402
G7. Science and technology will help to eradicate poverty and famine in the world	199	98	126	274	2.68	.048	1.256	1.577
G11. A country needs science and technology to become developed	74	49	117	459	3.37	.038	1.006	1.011

4.4.6 Attitudes to environmental issues

Zimbabwean life is predominantly agricultural. Almost all children are aware of the importance of the environment for livelihood. In the rural areas, people and livestock depend directly on the ecology.

It is not immediately clear if the high concern for the environment in **Table 4-45** is a result of classroom teaching or from every day experiences. Educational media such as National Geographic and general media coverage of environmental issues is admittedly quite widespread. Personal experiences also contribute to the awareness that there is need to do something about protecting the environment

4.4.7 Commitment to environmental issues

Table 4-45 Attitudes to responsibility and contribution to environmental protection

Item	Response Categories				Mean	Std. Error	Std. Dev.	Var.
	1	2	3	4				
D11. It is the responsibility of the rich countries to solve the environmental problems of the world	**395**	75	94	154	2.01	.046	1.241	1.541
D12. I think each of us can make a significant contribution to environmental protection	75	46	99	**496**	3.42	.037	1.001	1.002

Environmental issues are largely abstract in that the changes are very subtle. There are high frequencies in item D11 and D12 in categories 1 and 4 respectively. This indicates understanding of the items and an attitude of environmental responsibility.

4.5 Research question 4: What are learners' expectations for their future careers?

Factor analysis of the items on expectations for the future sorted out the views of Zimbabwean children into seven distinct categories. The factoring out of these items in **Table 4-46** shows a natural tendency of people to be assorted in certain career options.
The seven factors are informed by their total experience with science, in and out of school.

Table 4-46 Structure matrix of factors extracted for learners' aspirations

Factor groups	1	2	3	4	5	6	7
B11. Coming up with new ideas	0.709						
B25. Developing or improving my knowledge and abilities	0.66						
B10. Making, designing or inventing	0.601						
B9. Using my talents and abilities	0.594						
B13. Making my own decisions	0.388					0.355	
B24. Becoming 'the boss' at my job		0.719					
B21. Controlling other people		0.682					
B22. Becoming famous		0.677					
B20. Earning lots of money		0.533					
B7. Working with machines or tools			0.784				
B6. Building or repairing objects using my hands			0.761				
B12. Having lots of time for my friends				0.767			
B17. Having lots of time for my family				0.594		0.372	
B23. Having lots of time for my interests, hobbies and activities				0.51			
B5. Working with something easy and simple				0.467			0.388
B3. Working with animals			0.342		0.622		
B18. Working with something that involves a lot of travelling					0.62		
B8. Working artistically and creatively in art					0.479		
B19. Working at a place where something new and exciting happens frequently	0.362				0.45		
B16. Working with something that fits my attitudes and values						0.731	
B15. Working with something I find important and meaningful						0.654	
B1. Working with people rather than things							0.691
B2. Helping other people							0.645
B4. Working in the area of environmental protection			0.412				0.515

Extraction method: Principal Component Analysis
Rotation method: Direct Oblimin. Rotation converged in 18 iterations.

4.5.1 Factor 4.1 Creative capability

Table 4-47 Items that make up the factor 'Creative capability'

B11. Coming up with new ideas B25. Developing or improving my knowledge and abilities B10. Making, designing or inventing something B9. Using my talents and abilities B13. Making my own decisions	Creative capability Cronbach's alpha = 0.637

An alpha value of 0.637 indicates a fair degree of internal consistency of the items. Logical meaning of the item also indicates a good indication that education is valued for its ability to empower the learner to think and make objective decisions. It may not be difficult to link the creativity factor with the general high interest to learn many different things as seen in responses to section A, C and E. From different types of schools, the creativity factor was very highly regarded by all respondents. No gender differences were noted. The international pool of data shows the same enthusiasm for creative thinking in all children even those from rich countries. Most of the responses showed the learners thought that it was very important to be creative.

Table 4-48 Responses of Zimbabwe sample to factor 'Creative capability'

Item	not important	lo not important	lo very important	very important	mean	std error	std dev.	var
B9. Using my talents and abilities	29	15	75	**606**	3.74	.026	.690	.477
B10. Making, designing or inventing something	68	35	105	**515**	3.48	.036	.955	.912
B11. Coming up with new ideas	35	28	91	**566**	3.65	.029	.773	.598
B13. Making my own decisions	42	48	150	**483**	3.49	.032	.856	.732
B25. Developing or improving my knowledge and abilities	21	9	73	**617**	3.79	.023	.607	.369

4.5.2 Factor 4.2 Egoism

Table 4-49 Items for the factor 'Egoism'

Item	Cronbach alpha
B24. Becoming 'the boss' at my job B21. Controlling other people B22. Becoming famous B20. Earning lots of money	0.621

Table 4-50 Frequencies of responses to factor 'Egoism'

Item	not important	lo not important	important	very important	Mean	Std. Error	Std. Dev.	Var.
B20. Earning lots of money	75	32	112	**505**	3.45	.036	.979	.958
B21. Controlling other people	**246**	99	127	252	2.53	.047	1.276	1.627
B22. Becoming famous	151	66	117	**386**	3.03	.045	1.212	1.468
B24. Becoming 'the boss' at my job	130	60	143	**387**	3.09	.043	1.156	1.336

High frequencies in the *'very important'* category (4) indicate a strong ego. Item B21 is interesting in that opposite ends of the attitude scale *'not important'* and *'very important'* are about equal. Putting together category 3 *'important'* and 4 *'very important'* together the character of ‘controlling other people’ is quite strong. Numbers for these categories are highlighted for clarity.

There is a small gender difference between in the desire for authority and influence. Curiously it is the girls in the countries that have strong ‘gender equity’ policies where the women actually show a lower interest in this factor. Girls in African and Asian countries where the cultures do not give women as much gender equity seem to aspire more to achieving this control.

Items showing interest in authority, money and influence are summarised as Egoism. Such factors are seen as typical of individuals who like to be influential. There are also many people who are not interested in such responsibilities in life.

4.5.3 Factor 4.3 Do-it-yourself attitude

Table 4-51 Items that make up the factor ‘Do- it- yourself attitude’

Items	Cronbach’s alpha
B7. Working with machines or tools	
B6. Building or repairing objects using my hands	0.639

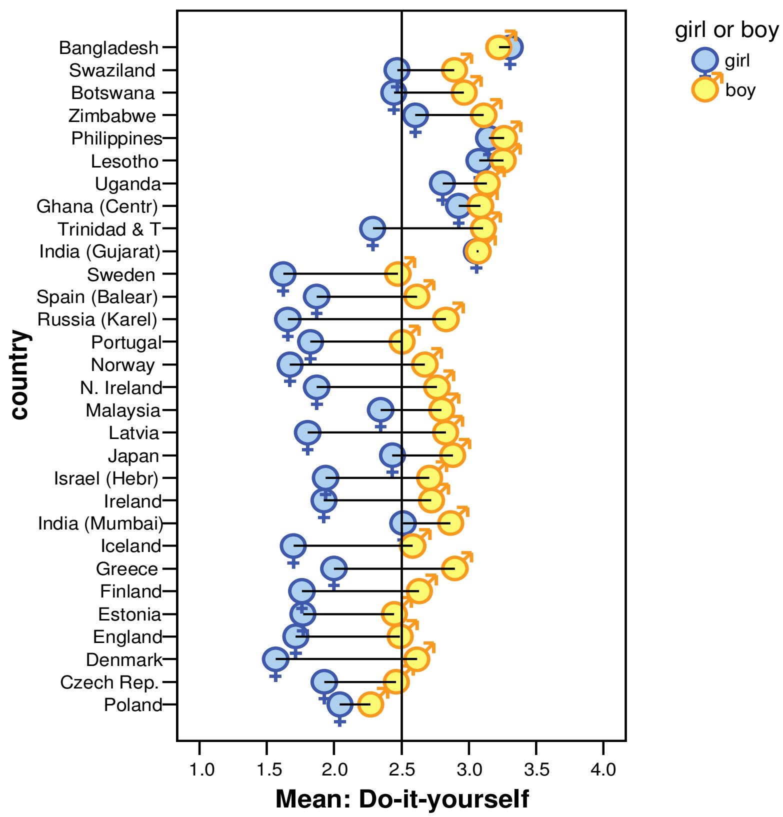


Figure 4-10 Comparison of the DIY factor the international pool

4.5.4 Factor 4.4 Leisure

Table 4-52 Items for the factor 'Leisure'

Items	**Cronbach α**
B12. Having lots of time for my friends	**0.767**
B17. Having lots of time for my family	
B23. Having lots of time for my interests, hobbies and activities	
B5. Working with something easy and simple	

Children in all the ROSE survey countries are agreed about leisure time, with no significant difference between rich and poor countries and between sexes. Alpha value testing the reliability of the items is 0.439. While this measure may be lower than other factors considered, the level of agreement from all respondents is strikingly uniform.

Table 4-53 Frequency table for factor 'Leisure'

Item	Response categories				Mean	Std. Error of Mean	Std. Deviation	Variance
	1	2	3	4				
B5. Working with something easy and simple	149	86	**136**	**349**	2.95	.045	1.196	1.432
B12. Having lots of time for my friends	182	122	**151**	**261**	2.69	.045	1.206	1.455
B17. Having lots of time for my family	69	45	**168**	**440**	3.36	.036	.964	.929
B23. Having lots of time for my interests, hobbies and activities	69	66	**151**	**438**	3.32	.037	.987	.974

4.5.5 Factor 4.5 Value and meaning

Table 4-54 Items that make up the factor 'Value and Meaning'

B16. Working with something that fits my attitudes and values	α= 0.691
B15. Working with something I find important and meaningful	
B13. Making my own decisions	

Table 4-55 Frequencies for the factor 'Value and meaning'

	not important	lo not important	lo important	very important	Mean	Std. Error	Std. Dev.	Var.
B13. Making my own decisions	42	48	**150**	**483**	3.49	.032	.856	.732
B15. Working with something I find important and meaningful	43	22	**99**	**557**	3.62	.030	.809	.655
B16. Working with something that fits my attitudes and values	51	32	**113**	**526**	3.54	.032	.873	.762

There were high frequencies in the categories 'important' and 'very important' for this factor.

Items factored out in the Zimbabwe sample and showed very good internal consistency and follow the same distribution internationally. Both sexes are again agreed in all countries about searching for meaning and value in what they like to do after school. Gender differences are not very large but it is interesting to note that girls in all the countries tend to have a higher inclination towards this factor.

4.6 Research question 5: What are the research aspirations of learners?

Item I in the ROSE questionnaire asked the children to imagine they were scientists:

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 . . . .

. . . .

Figure 4-11 Item I from the ROSE questionnaire

This question is good for eliciting free responses from the children about skills they really value in science for their life. There is always the caution however, that out of the many interests children have, some of the ideas they wish to pursue according to this question may be influenced by the preceding items in the same questionnaire. In their responses to this item, learners generally drew from their real life experiences and showed a desire to participate in confronting real life issues. Issues raised are ranked in Figure 4-12. The assumptions made by this question are that learners appreciate the role of scientific research as a generator of knowledge and solutions. The selection of research areas and investment into that research is also determined by the priorities which are set by society. There is a big debate here, about who determines what research must be conducted by the scientific community. This study asks 'If the learners were scientists, what issues they would like to research on?'

Medicine and health are the most common for the reasons shown in Figure 4-13; disease led mortality, finding a cure for AIDS, personal knowledge and humanity. The high frequency of these reasons suggests that most of the learners in Zimbabwe would want these issues addressed as a priority. If one considers the figures of HIV/AIDS in Zimbabwe in this decade the reasons for wanting to research on these issues suggests that learners have been adversely affected by HIV/AIDS and would desire a solution.

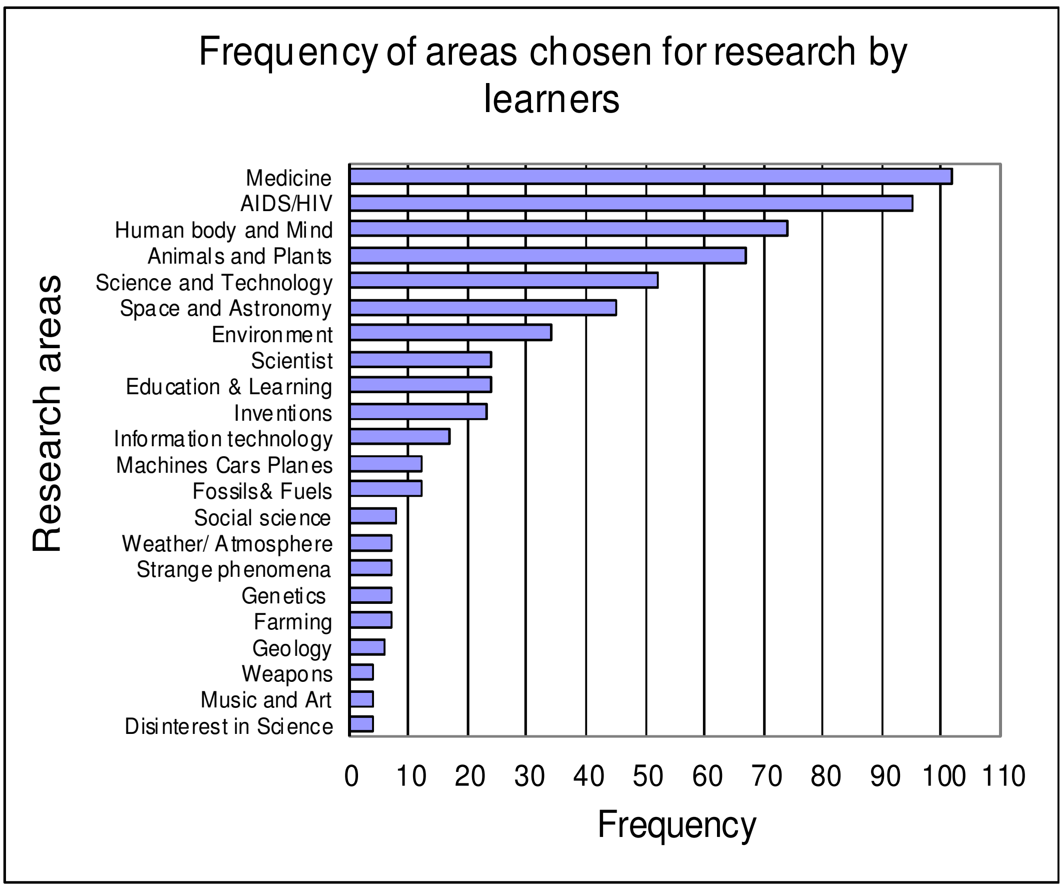


Figure 4-12 Areas of research interests expressed by Zimbabwean children

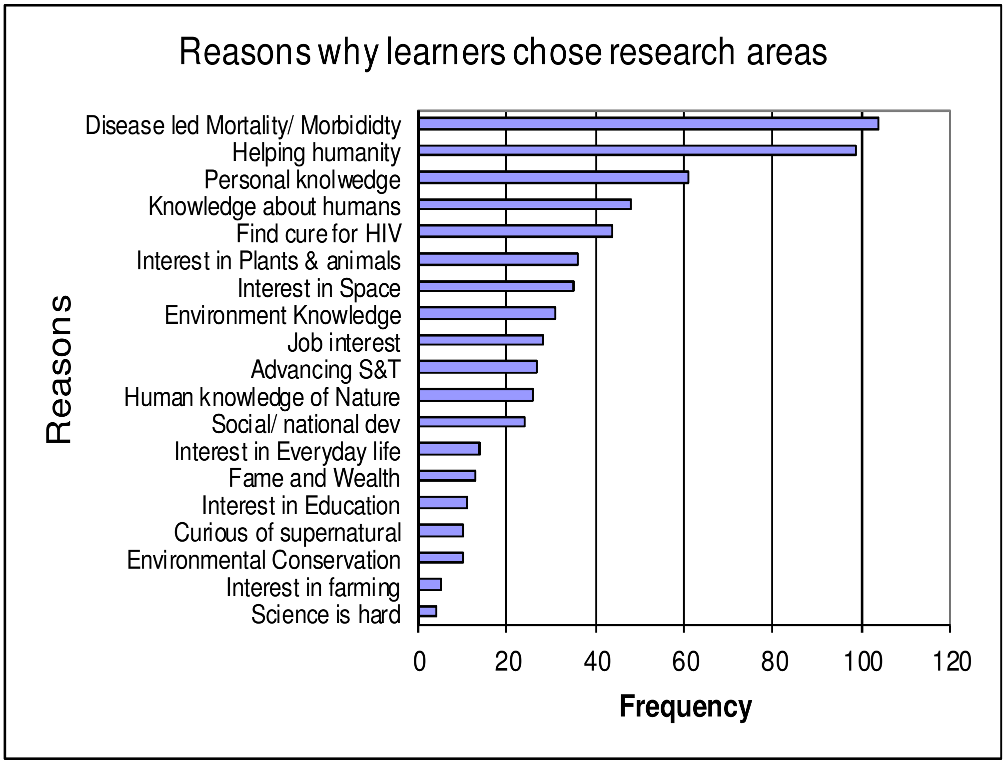


Figure 4-13 Reasons given for choosing particular areas for research

4.7 Conclusion

Results of some statistical tests, tables and trends are presented. Tests investigated the gender dependence of views. Tests also were done to show that the views of Zimbabwean learners sometimes differ from learners in other countries, but remain similar for some issues. For universal issues such as environmental responsibility, the nature of science, energy and others, learners show very similar trends in all the countries.

Background drop-line graphs were made for all the questionnaire items but only the Sections A, C and E are in the appendix to establish the worldwide trends and the gender linked nature of views and attitudes of learners. A wide range of views have been analysed in the form of factors in order to focus on the underlying attitudes. These analyses however still cannot explain the reasons why learners thought the way they did. Informed deductions and inferences can be made about several issues which it is hoped will enrich debate on the attitudes of learners.

Chapter 5
Discussion and Conclusion

5.1 Introduction

This chapter presents the meanings of statistical tests done on the research questions and the tentative conclusions that can be inferred from them. The main purpose of the study was to listen to the voice of the learner with a view to include their interests, expectations and ambitions into learning and teaching experience.

5.2 What are the interests of secondary school learners in science?

Learners responses in Sections A, C and E (ACE) were arranged in order of decreasing means. Responses with high means indicate those variables from the questionnaire in which the respondents are most interested. Means that were higher than 2.5, indicated a positive interest in an issue. The ROSE instrument does not identify reasons why these variables were popular in the Zimbabwe sample, many speculations are possible.

Sections A, C, E items were also ordered according to gender. The top ten interests are compared and the gendered nature of views was also confirmed by independent sample t-tests. This test confirmed that learner' views depend on gender.

Girls were found to have high interests in issues that have to do with caring, beauty, and healthy nutrition for themselves and others. Girls are conscious of their bodies and want to look their best earlier in life than boys. Boys on the other hand tend to like more hands-on activities, technical and more outdoor activities.

5.2.1 Desire for a healthier lifestyle

The most popular variables in Section E suggest interest in human health, especially reproductive behaviour. Knowledge about cancer, HIV, nutrition and physical activity are closely related to healthy lifestyles. It can be taken that the lack of knowledge about these contributes to a reduced quality of life. Girls have a desire to learn about personal health matters more than boys of the same age.

5.2.2 Experiential learning

The interests of boys and girls are quite similar with both sexes selecting the same 7 out of ten most popular items in Section E. In the least popular items, boys and girls overlap in 7 out ten items. The most popular items for girls also suggest an interest in personal health, reproductive behaviour and caring for the welfare of other people. While boys also have interest in reproductive health issues, they seem to show a marked interest in technical issues. Girls have more varied interests whereas boys are into 'how things work'. Increase in technology products such as information technology, energy convertors in everyday life, more knowledge in science sustains interest in all learners.

This age where boys are interested in 'How things work' is the best time to provide for constructive hands-on teaching which can capture and maintain their interest in science education. This marked interest is an opportunity for teachers to engage this natural interest to create more experiential learning. Zimbabwe would need to invest more equipment and teaching technology to make school activities more practical and contemporary. The choice of things to study and how to present ideas needs to be kept modern and related to real life experiences. An example is the computerisation of science laboratories and spending time studying and using the contemporary applications such as mobile phones, internet and other digital devices. Failure to talk about new scientific and technological applications makes science education seem irrelevant to the lives of the learners.

5.2.3 Ability to make decisions

At the average age of 16, learners are aware of issues that are topical to them. Ideas are likely to be formulated from lessons, media and information from around them. This finding persuades one to think that the learners can and should contribute to the curriculum if they were allowed to make periodical inputs of "What do I want learn about". Responses from one year group could influence the curriculum structure of the next year group. In my own view, the science curriculum could be reviewed periodically. This is considering that issues change and global technologies change rapidly. Debate and practice in environmental issues, electronic technology and a host of several other things impacting daily life are changing all the time. Most of the issues chosen by respondents do not appear in the science curriculum and the last review of the curriculum was in the eighties (The Standard, 8 May 2010). Lack of frequent review may be due lack of skills or finances, but it has the effect of lowering the usefulness of the curriculum components to the lives of the learners. School graduates from an out-dated curriculum are equally irrelevant to their time. The Zimbabwean (4 October 2010) quotes the Chief Executive officer of Zimbabwe Teachers Association:

> *'Things have changed, life has changed and education should be used to prepare learners to face life.......We support the revision of the curriculum. Under the current system, we are condemning children to poverty.'*

The voice of the learner is here saying that what matters for contemporary life is not available in the curriculum and the curriculum is not changing fast enough.

5.2.4 Gender differences

The ROSE study established that interests are gender linked. From this realisation (rather a confirmation) established gender stereotypes cannot be ignored. It is noticed here that by the age of 16 years, boys and girls already have a definite knowledge of their different interests. The system of education often does not treat the girls any differently from the boys despite them having different persuasions. Instruction is the same for both boys and girls, so stereotypes do exist. Literature is awash with the gender disposition of learners to mathematics and science education (Nosek *et al*, 2009). The underlying reason for girls' differences with boys happens to be their gender stereotypes, and if this must be overcome, then teaching and learning processes must engage the natural differences that exist in girls. A wide distance exists between gender choices in items such as A37 which suggests that girls are much more aware of their food choices for fitness and boys are not as concerned. Similar graphs in other items suggest that girls are more conscious of their figure more than boys. Schreiner (2006) made similar findings where it concerned cosmetics, food and eating disorders, and cosmetic surgery in Norwegian students.

The natural caring attitude tendency of girls predisposes females to a nurturing role and the curiosity and tinkering nature of boys predisposes them to scientific and mechanical roles. Even if there are role models of both sexes, the nurture predisposition of girls makes them to need to follow their nature first and then everything else later. So the expectation that women should be able to do exactly the same as men is an oversimplification of the complex nature of girls.

5.2.5 Diversity of interests

A wide range of interests from the Zimbabwe sample emerges from the factor analysis. This diversity of interests is largely from the sum total of influences that come to learners, either from school or the environment. The crucial point is that there are interests that did not exist a few years ago and they are in the learners. Experiences with the devastation of HIV are evident in the learner's interest to deal with control of disease.

The array of interests in the study, were determined by the instrument used. By suggesting a particular activity, the instrument gave options which may not necessarily be a measure of what learners were interested in. At the same time with unguided responses, it would not be possible to obtain so much information from the respondents. The fact that the questionnaire gave the option of not answering a question if the respondent was unaware, unsure or simply did not want to talk about a particular issue means the interests shown truly reflect wilful learner opinions.

The range of interests is also an indication of the extent to which learners are getting knowledge from around them. The list of factors and their Cronbach's alpha values in Table 5-1 shows that learners are more interested in more contemporary, active issues which they actually experience every day. Science education needs to remain contemporary and the experiences of learners needs to get out of the laboratory and have more to do with real life.

Table 5-1 *Summary of factor analysis of Zimbabwean learners' interests*

	Factor Summary	**Cronbach's alpha**
1	Information technology	0.798
2	Control of disease	0.792
3	Atoms and Energy	0.755
4	Spirit and extrasensory perception	0.741
5	Science and knowledge	0.730
6	Energy in everyday life	0.722
7	Earth Phenomena	0.703
8	Reproductive Biology	0.679
9	Space Science	0.671
10	Radiation and the human body	0.661
11	Responsibility for the environment	0.660
12	Health and fitness	0.613

5.3 Learners opinions of science education and Science and Technology

A positive attitude towards science is seen by doing science in practice. For most Zimbabwean learners, the practice of science is seen as requiring much money. Indeed instruments like binoculars or a tent (Item H30 and H21) have to be purchased. The level of interest in interaction with electronic equipment indicates science and technology making inroads into scientific experiences. Information transfer, processing and storage are increasingly common in Zimbabwean life. The internet, information processing and storage, social networks, mobile phones are technological out-of-school experiences applications that have pervaded daily life. These and other applications need to be understood theoretically so that Zimbabwe can sustain their use. Development of scientists, technicians and engineers who can maintain the developmental momentum of information technologies is crucial for the country and the region.

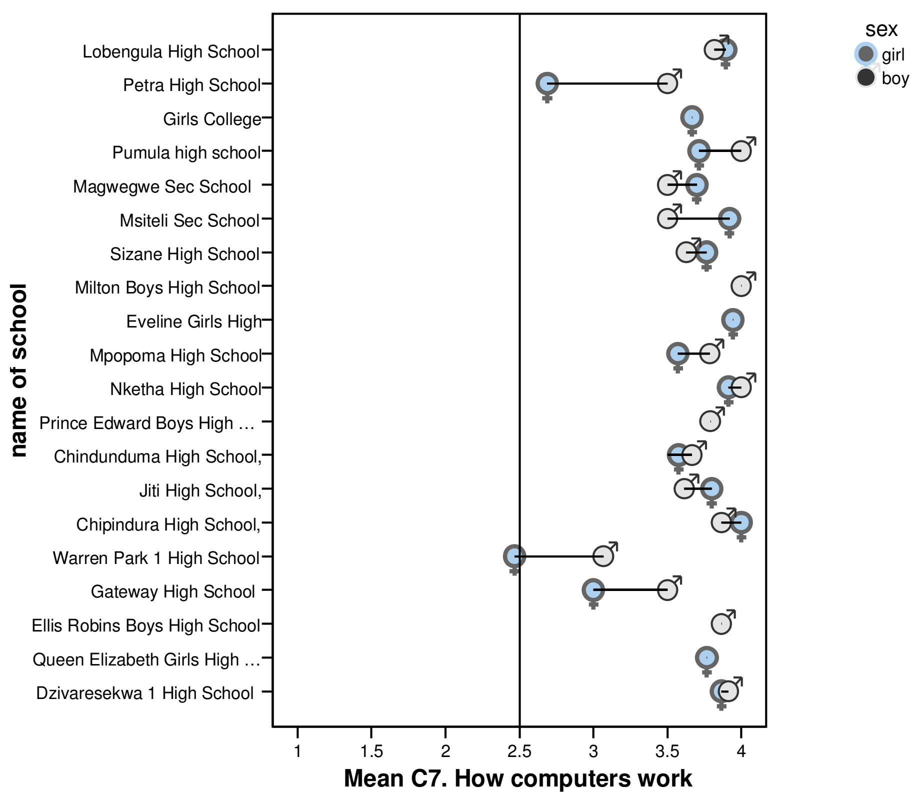


Figure ***5-1*** and

Figure 5-2 show the level of interest in information systems that are increasingly common and indispensible for modern life. Except in two schools, all learners are highly motivated.

This how far learners' opinions have moved over the years that these issues need to be the medium and content in which science experiences are made available to learners.

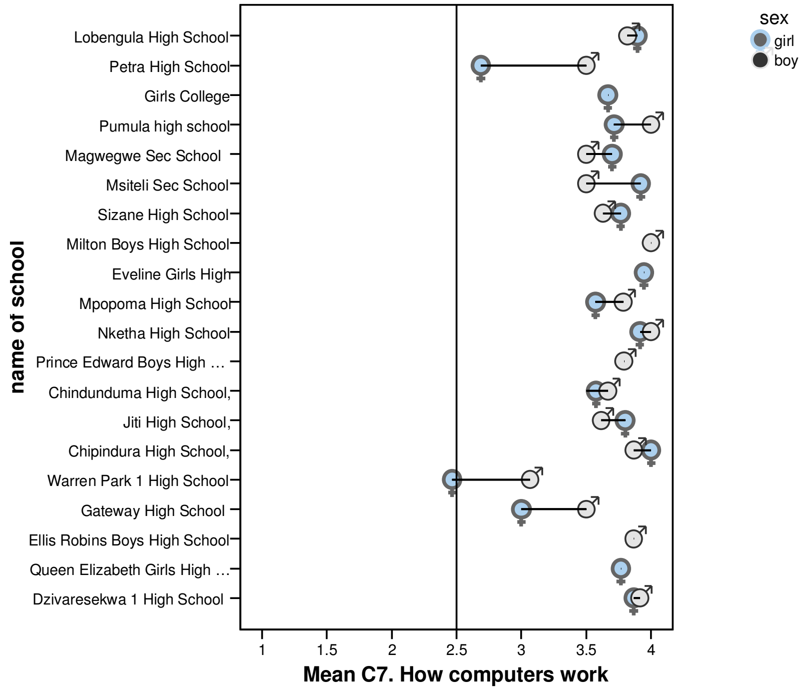


Figure 5-1 Drop line graph for Item C6 from Zimbabwe

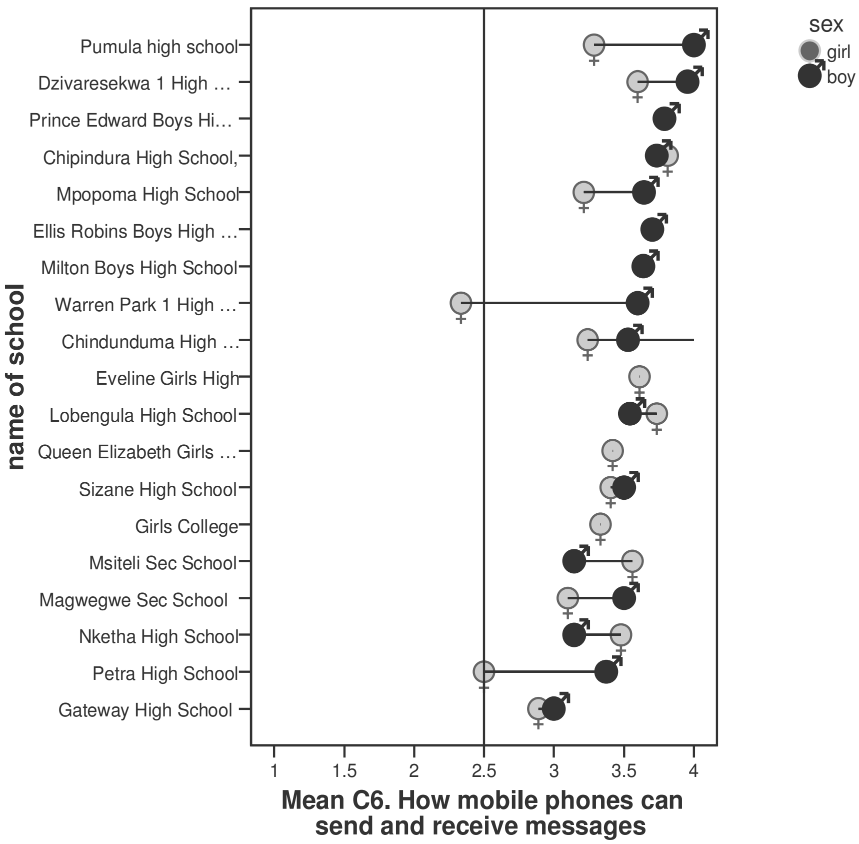


Figure 5-2 Drop line graph for Item C7 from Zimbabwe

Research aspirations of learners

Results from the open ended item sought responses without guiding with Likert options. This is the only item that would give ideas that are not influenced by the researchers. The commonest issues from Zimbabwean learners are medicine, HIV/AIDS and other aspects about the human body and mind. The priority given to HIV/AIDS and medicine by Zimbabwe children is not surprising. The reasons given by the majority of respondents are that HIV and other diseases have generally led to many deaths and general morbidity of the population, an obviously undesirable situation. The hardships precipitated by this morbidity and elevated mortality are experienced daily by the children in their lives. The compulsion to research into HIV is to find a cure for AIDS, help suffering people and help raise standards of living to better levels. This is an expression of a desire by children to use science education to change condition of life in their communities.

At the bottom of the list are curious choices. Farming, weapons, music and art are phenomena that have been known to mankind for a long time. Learners may be so familiar with all these activities that they do not regard them as areas needing much research.

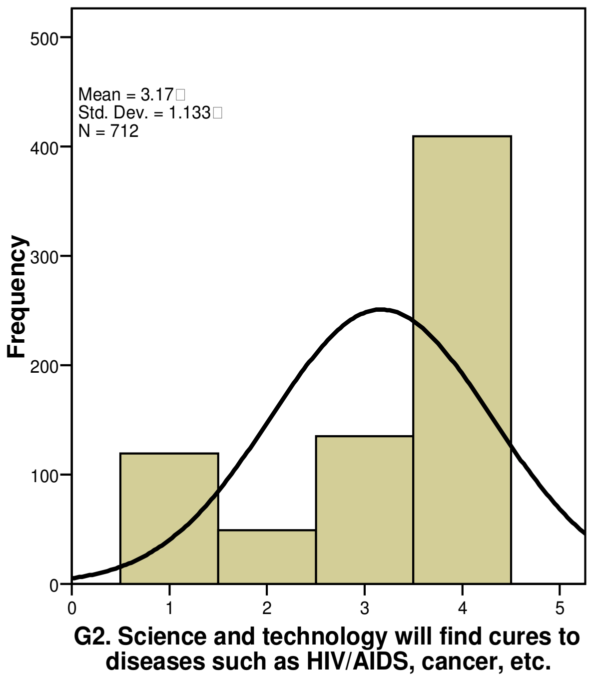


Figure 5-3 Confidence that S&T can be used to solve problems

There is confidence in learners that science and technology can find solutions to problems. In section I of the ROSE questionnaire, learners expressed the need to solve HIV/AIDS problems in Zimbabwe. Learners look to science and technology to find solutions to problems and they are taking responsibility of finding the solutions rather than look to other nations to do it for them.

Personal Knowledge

Desire for personal knowledge and skills was one of the main drivers of the research interests of children. There are many interrelated dimensions to the knowledge interests expressed by children. What I have called personal knowledge is where the children have expressly indicated that the reason they chose to research on a particular issue is because they are curious about it, or have a desire to address a particular challenge. However the knowledge and skills are intrinsically connected to other interests. There are several interests in knowledge about the human body, animals and plants, technology, space and extra-terrestrial life. Such interest in knowledge is a necessary condition for development (Lewin 2000). Basic research is born out of sheer curiosity among other imperatives and the products of such research find applications that lift the quality of lives of whole communities.

It will be recalled that in exploring the most popular items in Sections A, C and E, the issues of HIV and AIDS, reproductive health, disease and human welfare emerged at the top of all the items. In the more expressive Section I, the same trend emerges. The five most important reasons for choosing areas of research are to confront disease led morbidity and mortality and helping humanity. This displays a maturity in the Zimbabwean teenagers that is borne out of experiencing human suffering from disease.

At the bottom of the list are issues like weapons which have really been the instrument of much grief in the world. It is interesting to note that learners are already (at 16 years of age) able to distinguish that weapons are not as important as health.

5.4 Attitudes towards environmental responsibility

Significant attitudes shared by children in all the participating countries are:

- People need to take more care of the environment
- Everyone can do something about the environment, not only the rich countries.
- We can still find solutions to environmental problems

Views of Zimbabwean youths compare very consistently with those of youths from other countries of a similar economic and cultural background. The patterns seem to suggest that the children from developed countries are not very keen on issues which would be expected of them by adults. Given the exposure they have to technology driven cultures and economies, it would have been expected that they are more stimulated to study science. However, results suggest that children in less developed are more interested in science and technology issues.

The results suggest that the learners are convinced that the environment needs to be protected and they are ready to do something about it. In the context of the global dialogue on the environment, such a commitment by youths is a guarantee that future adults will continue paying attention to environmental issues.

5.4.1 Similarities in attitudes

There are strong similarities in factors that have to do with principles and quality of life such as ‘Value and meaning’ and ‘leisure time’, egoism and ‘creativity’. These factors describe fundamental human aspirations and they transcend cultural and economic boundaries. All people are equally human when it comes to choosing to have leisure, even if the forms of expression of leisure may differ. When it comes to ‘Value and meaning’, it ceases to matter, what artefact conveys the sense of value or how do we define ‘value’. The data does not explore such meanings but the deduction here is made from the prima facie meaning of the concept of ‘value’ in one’s life.

5.4.2 Attitudes towards school

Several other items did not form a discernible pattern of factors and some factors tended to combine items that did not make logical combinations. These were ignored as not having enough meaning besides simply bundling up together in the statistical rotations of factor analysis. The lack of interest shown by children in rich countries makes one to perceive a sense of depression with the state of so called developed society. To an African researcher, it leaves questions about the meaning of life for the learners in developed countries. Why is it that they have so much more material and infrastructural facilities that could guarantee comfortable life, yet they do not seem to care about learning? Does it mean that interests of African learners are driven by their comparative lack? That the children seem to behave the same when it comes to issues concerning global environmental issues and human value systems may seem to suggest that, material affluence or lack does not change the core attitudes that make us human.

5.4.3 Valuing science

It makes a large difference to life if one learns to value science as a thought process. Many Zimbabweans believe in myths and ancestral gods. An attitude of valuing and appreciating science as a way of life means science education is influencing people to think more objectively. The age of the learners gives a hope that as they become adults there is going to be a change in the way citizens think and act. These learners can be relied on to become a more enlightened citizenry. There is even a bright future for the development of science and technology as the current youths are showing an interest in science.

A learner who attaches value to science in the laboratory and in daily life is likely to develop a more epistemic appreciation of its possibilities and limitations. The implication of this knowledge is the motivation and seriousness with which learners approach science as a science and way of life and the overall construction of a scientific capital.

Trust in Science and Technology

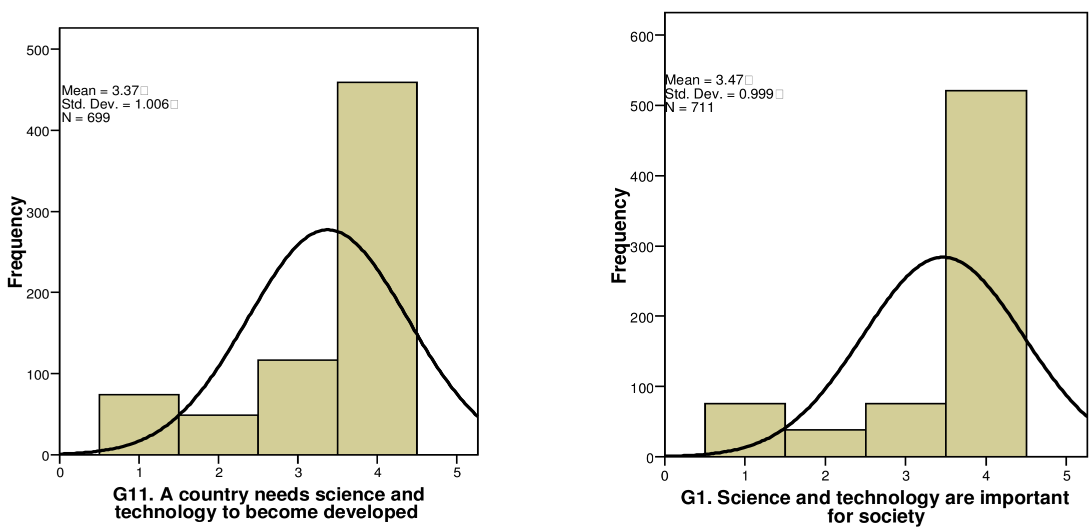


Figure 5-4 Zimbabwe responses to items on importance of S&T for development

The responses to the ROSE questionnaire have also established that learners in Zimbabwe have matured enough to understand the opportunities and limitations of science. Understanding that science and technology are crucial for development is fundamental to the capability approach in the modern world. Challenges faced today have to be faced by technological approaches. Some problems result from wrong use of technology and so developing this awareness in learners guarantees that future leaders understand the need for proper selection and development of technology.

5.5 Out- of-school experiences and opinions

Experiences with information technology and other mechanical applications were explored (Factor 3.1 and Factor 3.2) and it was found that more than 50% of the respondents had some experience with modern technology. At this point we can consider that 'lo agree' (3) and 'agree' (4) really mean real experience, differing only in frequency of use. Some outdoor activities were not common in Zimbabwean because of the economic stress of the country in 2003 (when data was taken). However, frequencies of experiences show that about 50% and more had outdoor experiences. Experience opens new possibilities and hence worldviews. Opinions of most respondents showed an understanding of the nature of science by doubting what scientists say and knowing the limitations of science and technology in solving problems. It is known that while science and technology can address many problems, some other problems are also created by science and technology. Learners also showed that science and technology are not the cause of environmental problems.

Items G1-G7, G11 and G16 (Appendix B) had very high frequencies of responses that showed mature opinions about science and technology. It suggests that school science and life experiences helped form opinions about science and technology.

5.6 "How important are the following issues for your potential future job?"

Section B of the ROSE questionnaire asks learners to express the importance they attach to 26 issues for their potential jobs or occupations. This section required them to make an introspection of their aims for the future. Responses to the items in this section can be used to look into the mind-set of the learners to find what really matters to them. It reveals the values they consider precious and desirable to be achieved after school. It is important to realise that most of what the learner regard as important are aspirations they formulate from their life experiences.

Some respondents in the Zimbabwe sample were from farming communities. Informal discussions with some of them revealed aspirations like being a farm guard, a farm owner, and a shift foreman or tractor driver. Three factors 'Creativity ability', 'Do-it-yourself' and

‘Value and meaning’ had very high frequencies on the positive categories of the Likert scale. Their means were all in the ‘lo important’ and ‘very important’ categories. These factors reflect a mind-set that is set on achieving. Learners do expect to be empowered to do things for themselves. This observation challenges lack of practical work in science education as we find in many under-funded schools. It also challenges science experiments which end at verifying theories instead of problem solving activities that provide creativity and meaningful learning.

Do-it-yourself factor

Girls are quite decided they do not want to work with machines and tools, build or repair things. This sentiment is observed in all the countries considered. Boys have a significantly more positive view in all countries. In low income countries, such skills are very useful for everyday life. In richer countries, machines and spares are more easily available, unlike in low income countries where most hardware is imported. Do-it-yourself (DIY) skills can empower people to maintain, modify, repair and even design appropriate technology for themselves. Low income countries are also the one with very high unemployment levels; DIY skills provide lifelines in small and medium scale enterprises. Informal sector economies are a significant player in human development in the Asian and now the African economic landscape. With over 80% unemployment in Zimbabwe, the importance attached to hands-on skills is good potential for social development.

5.7 Are Learners’ voices heard?

In searching for learners’ interests, aspirations and expectations, the study could hear a decisive set of thoughts which learners are saying. Analysis established that the choices they made are related to their gender and also the geographical and economic circumstances. From the high interest levels in developing countries to lower interest levels in developed countries one can infer what really matters to teenage learners.

The importance of these voices is that there is an increasing need for learners to engage in democratic practices, to listen and to be listened to and engage the learner in practical ways in respecting and honouring opposing arguments. Democratic citizenship in a global community will require that learners start free thinking and taking responsibility for their decisions at an early age. The high interest level shown by African learners is encouraging in that they are more ready to take responsibility for important issues. For planning purposes it is important that the learner views come into serious consideration in policy and curriculum development.

One implication for teaching is to transform the focus of teaching from the traditional 'banking' concept of education (Freire 1970, Kolb 1984) to a purposeful engagement that listens to what the learners want, how they want to learn and what they want to learn. The things that learners are interested in are real life challenges that require teachers to select their content with the contemporary changes in their world. An example is the technological evolution. Real life experience showed that learners are aware and getting experience in information communication. This does not mean formulating the curriculum only on what learners want, but allowing the curriculum to evolve with the real life experiences of the learners. Many school programmes however do not include anything to help learners understand the physical principles of the technology in use every day like mobile phones, internet and radio. Another example is that various concepts if science must be empower learners to adopt healthy lifestyles, such as reproductive health, nutrition and care for the environment. Several other dimensions depend on teachers listening to learners and also learners to listen to the voice of the community. Engaging to voice of the people involved tend to bring better understanding of each other, the start of democratic participation in a citizenship.

5.8 Science education for the capabilities approach

Nussbaum recasts the capability approach into a four pillar framework which enshrines essence of development. The first pillar; Learning to know: Practical reason comes alive in the ROSE study in that it elicits from the learners themselves what they are wishing to engage their thoughts and actions in. Science education must play its role in empowering learners to achieve a life they choose to live. In much of the real practice of science education, it is separated from real life interests, aspirations and expectations of learners. Relevant science education would be a science education curriculum that meets the needs, expectations and cherished values of the learners. Outstanding work is achieved in science education curricula in many countries but this study also finds other things that are valuable to curriculum evolution.

Inclusion of learner interests, attitudes, and life experiences of learners, expectations and aspirations of learners in the teaching- learning enterprise is fundamental to enabling learners to situate science in their mind sets. This requires introspection into the manner in which teaching is done. The most fundamental characteristic of an enabling environment for learning is freedom. This freedom is in allowing learners to learn those things which they value. Freedom creates a personal autonomy, a responsibility in the learner which empowers him to take control of the destiny he or she chooses. At the same time the learner also needs tools to help him make wise and informed decisions about his future. Exercising personal autonomy requires that the learner understands the constructive use of assessment as an informative instrument rather than judgemental practice. This way Nussbaum's second pillar is achieved; Learning to live together: building potential through social capital. The human being is a social animal which, besides all the science and technology, also needs to have good interpersonal skills and social skills. Science education should therefore promote the ability to live together with other animals and sustain the environment in which we live.

The ROSE has established that the learners are already members of a global community with varied views for different phenomena. Showing the existence of differences is part of the appreciating diversity in the world. This is a simple way of nurturing democratic citizenship of a wider community than their own local space. Consciousness of citizenship is a basis for taking local responsibility for issues that lead to global welfare. Concern and responsibility for the environment is one attribute that must rest in the hands of the learners themselves for them to make wise local decisions.

The third pillar of the capability approach refers to Central Human Functional Capabilities of "Life", "Bodily Health", "Bodily Integrity" and "Control over One's Environment" (Radja, Hoffman and Bakshi, 2003). Items on the ROSE study are chosen to elicit the functional capabilities of learners. Results show a constructive engagement of learners with the development of a wide range of skills that are necessary for development. While gender stereotypes do appear in the responses, the more important collaboration of boys and girls emerge in the common interests in that relevant science fosters those aspects that play down on gender stereotypes. Events in the world continue to show an increasingly loud voice from the youth in spheres such as shaping the market of the products of science and technology. Youth make a larger percentage of world population and it is their tastes that influence some technology designs for consuming information products. An example is the way consumption of music, messaging and broadcasting is influenced by a youth market. Experiences outside the classroom are learning opportunities that enable the teaching and learning enterprise to regard the real world as one big laboratory of life feeding the multidisciplinary demand for knowledge and skills in the learner. This is a departure from traditional discipline (subject) teacher-centred teaching. The learner wants real world experiential learning which brings the context of the world into being in his life so can mature his capabilities.

Computer education is an example of real world problem solving that directly empowers the learner to become employable, start their own business or just have real problem solving skills. There is almost no ‘border crossing’ or dilemma of contradicting worldviews in the same learner because the leaning and working are seamless.

Changing the traditional methods of teachers will prove difficult. Teaching as a facilitator of capabilities development will require that teachers themselves be the first learners of listening to learners. Including learners’ voices in the science education discourse requires a change of paradigm for the teachers themselves. It would be suggested that intense in-servicing of teachers is required for them to faithfully engage learner interests, aspirations and weaknesses. As learner issues are attitude driven, there is need for the teachers to seek to understand learner’s voices by putting themselves in the shoes of the learners. Learner voices speak according to their gender, economics, historical experiences and prospects for their future. Listening to views of learners does not mean basing curricula on what learners want only, that would be abdicating adult responsibility. However imposing adult voices on learners denies them relevance, meaning and even alienates them from the learning-teaching process.

Without relevance and value of the learning to their life, learners do not see the benefit of school and problems of discipline, disinterest and poor performance becomes real. There are serious threats to respecting relevant education: continuous change of curricula will cost much, it will require much more work for teachers, will widen the scope of school curricula and can easily become laissez faire. Poverty, politics and socio-economic conditions have a competing effect on learners’ motivation and commitment to the learning-teaching enterprise. Some of the relevant interests of learners are not catered for in schools. This has the implication of needing to expand the school system to include what is traditionally not in the mainstream school. Whatever efforts are more likely to succeed if the learners are motivated to achieve, given the academic space, relevance and genuine respect by the teacher. In sum, relevant science education creates agency in the learners. Sen (1999) says of agency that the individual is

> *"someone who acts and brings about change, and whose achievements can be judged in terms of her/his own values and objectives, whether or not we assess them in terms of some external criteria as well"*

Change here is positively assumed and is also assumed to be guided by enlightened reasoning, within sound social boundaries to achieve desired developmental outcomes. Thus the capabilities of learners are enhanced for the good of global development. The four pillars of human education and the central human capabilities are therefore likely to be achieved if more thought is given to applying ourselves to making science education relevant to the learners.

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7 Appendices

7.1 Appendix A The ROSE Questionnaire

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 students 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 students 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)

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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 interes-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 interes-ted			*Very interes-ted*
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			*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 interes-ted			*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.)

		Disagree			*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 interes-ted			*Very interes-ted*
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 interes-ted			*Very interes-ted*
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.)

		Disagree			*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.)

		Disagree			*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			*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			*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			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 . . . .

. . . .

. . . .

. . . .

. . . .

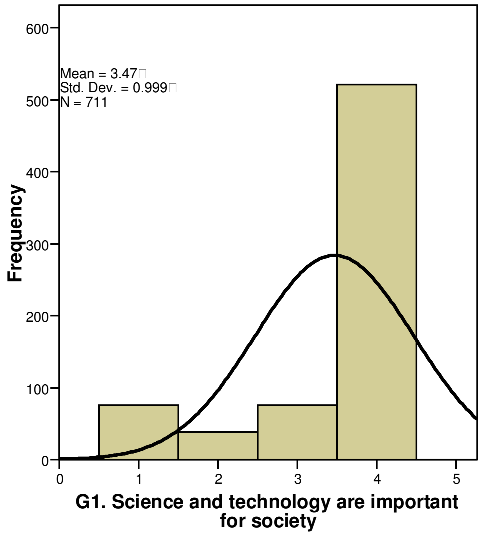
J. How many books are there in your home?

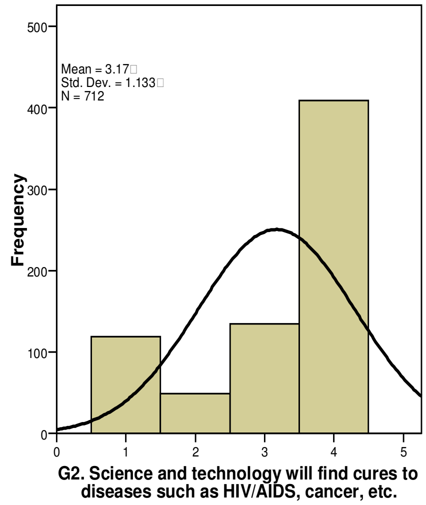
There are usually about 40 books per metre of shelving. Do not include magazines.
(Please tick only one box.)

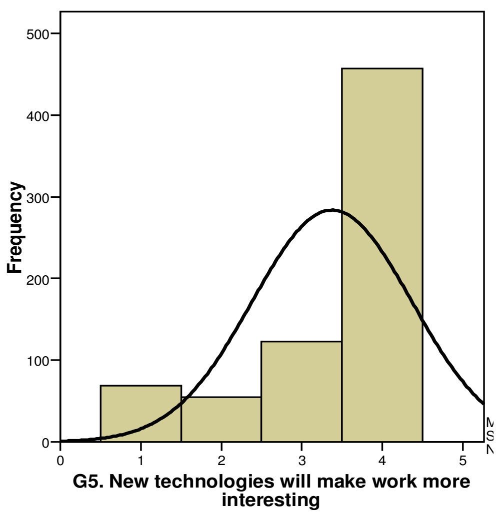
None .... □
1-10 books .... □
11-50 books .... □
51-100 books .... □
101-250 books .... □
251-500 books .... □
More than 500 books...... □

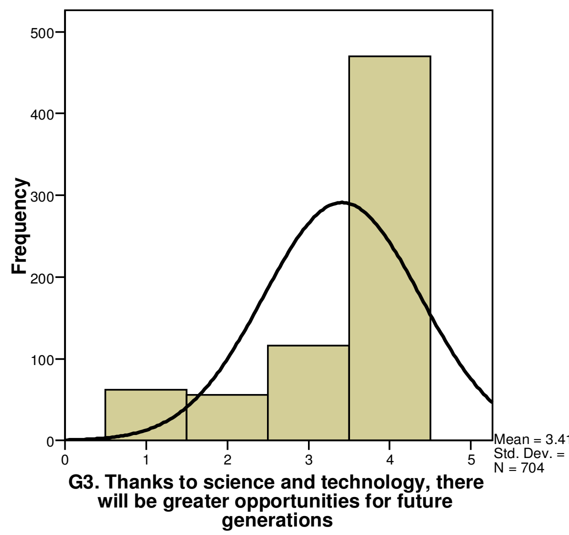
7.2 Appendix B

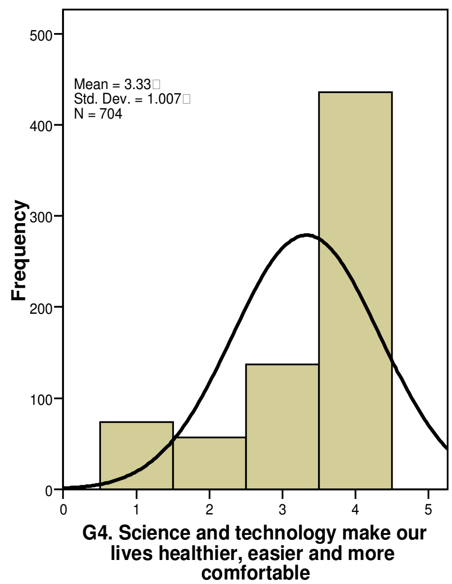
Zimbabwean learners' responses to Science and technology items

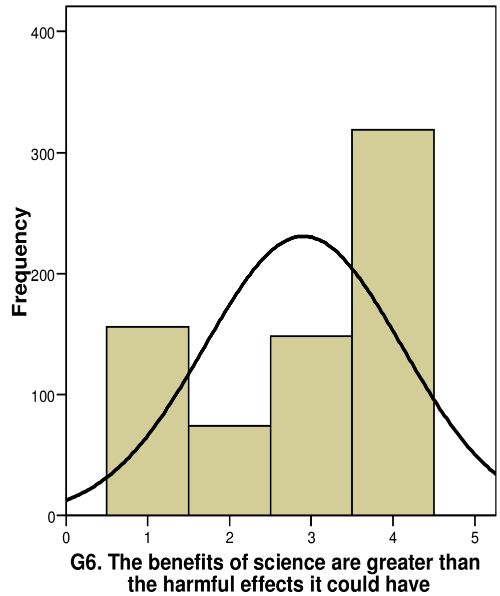


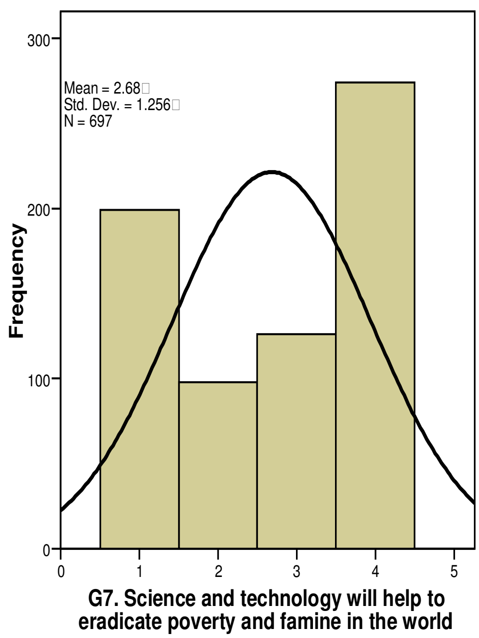


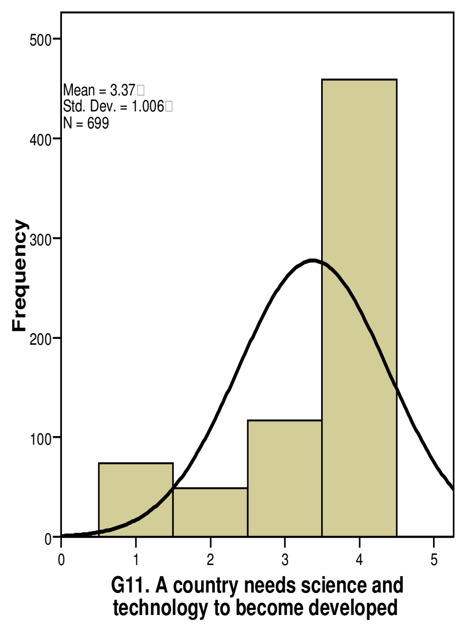


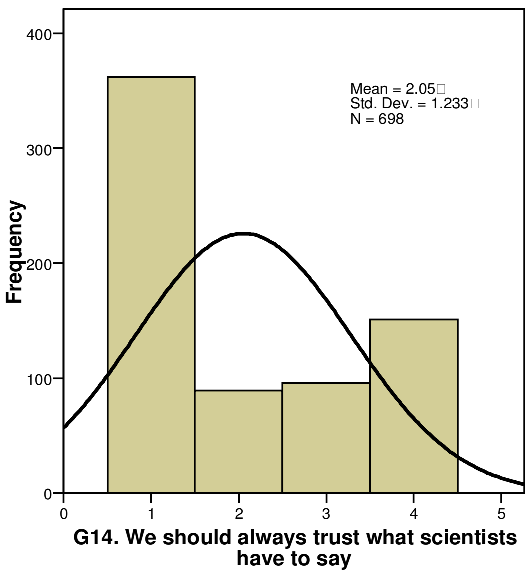


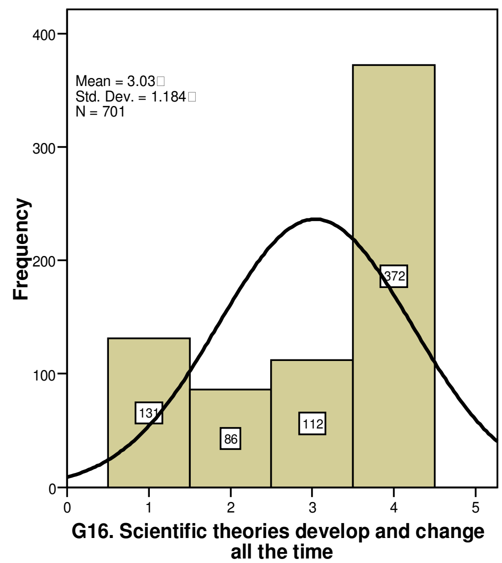

Mean = 3.33
Std. Dev. = 1.007
N = 704
Frequency
0
100
200
300
400
500
0
1
2
3
4
5
G4. Science and technology make our lives healthier, easier and more comfortable


Frequency
0
100
200
300
400
0
1
2
3
4
5
G6. The benefits of science are greater than the harmful effects it could have


Mean = 2.68
Std. Dev. = 1.256
N = 697
Frequency
0
100
200
300
0
1
2
3
4
5
G7. Science and technology will help to eradicate poverty and famine in the world


Mean = 3.37
Std. Dev. = 1.006
N = 699
Frequency
0
100
200
300
400
500
0
1
2
3
4
5
G11. A country needs science and technology to become developed


Mean = 2.05
Std. Dev. = 1.233
N = 698
Frequency
G14. We should always trust what scientists have to say


Mean = 3.03
Std. Dev. = 1.184
N = 701
131
86
112
372
Frequency
G16. Scientific theories develop and change all the time