University of Stellenbosch
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Public Understanding of Science and the out-of-school Scientific Experiences of Grade 11 Learners

An assignment submitted in partial fulfilment of the requirements
of the degree of Master of Philosophy (STS)

by

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Declaration

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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April 2004

Abstract

This study is an exploration of the outside the classroom scientific experiences of Grade 11 learners, as indicators of their interests, public understanding and engagement with Science and Technology.

The out of school scientific experiences, interests and feelings of being informed about scientific issues, debates and developments of male and female grade 11 learners are described and then compared to ascertain significant differences.

This investigation departs from the hypothesis that science teaching and learning focuses more on concepts, laws, principles and formulae with very little reference to science-related public issues and everyday life experiences of the learners.

Gender differences and motivational traits related to the students' preferences for particular types of learning activities and needs are not considered in science curriculum planning and design and also in classroom teaching. This leads to boredom and diminishing interest in science among learners.

The study analyses data from a survey of a sample of five schools with two hundred and twenty five Grade 11 learners. Tables of descriptive findings, analysis of variance and post-hoc comparison of means to analyse and interpret data from the learners are used.

The researcher finds that generally learners have never had the scientific experiences described or seldom engage themselves with scientific activities, issues and debates beyond classroom science. Learners expressed interest in scientific issues and developments but indicated that they were not informed about such issues and developments. The results of significant differences showed that the outside the school scientific experiences, levels of interest and being informed of male and female Grade 11 learners differed.

The study has implications not only for science curriculum planners and designers but also for science teachers and further research in the field of public understanding of science.

Opsomming

Hierdie navorsing behels 'n ondersoek van die wyse waarop graad 11-leerders wetenskap buite die klaskamer ervaar, wat dan as aanwyser van hulle belangstellings, openbare begrip van en betrokkenheid by Wetenskap en Tegnologie gesien kan word.

Die manier waarop wetenskap buite die skool ervaar word, belangstellings en gevoelens ten opsigte van ingeligtheid omtrent wetenskaplike kwessies, debatte en die ontwikkeling van manlike en vroulike graad 11-leerders word beskryf en dan vergelyk ten einde betekenisvolle verskille vas te stel.

Die ondersoek neem as vertrekpunt die hipotese dat die onderrig en leer van wetenskap hoofsaaklik op konsepte, wette, beginsels en formules fokus met baie min verwysing na openbare vraagstukke wat met die wetenskap en die leerders se alledaagse lewenservaringe verband hou.

Geslagsverskille en motiveringseienskappe wat met die leerders se voorkeure vir besondere soorte leeraktiwiteite en behoeftes verband hou, word nie tydens die beplanning en ontwerp van die wetenskapkurrikulum of tydens onderrig in die klaskamer in ag geneem nie. Die gevolg is verveling en 'n afname in leerders se belangstelling in wetenskap.

Die navorsing analiseer data verkry deur middel van 'n opname onder 'n steekproef van vyf skole met tweehonderd vyf en twintig graad 11-leerders. Tabelle met deskriptiewe bevindinge, variansie-analise en *post hoc*-vergelyking van gemiddeldes ten einde data oor die leerders te analiseer en te interpreteer, word gebruik.

Die navorser het bevind dat leerders oor die algemeen nooit die wetenskapservaringe soos beskryf, gehad het nie of hulle selde besig hou met wetenskaplike aktiwiteite, vraagstukke en debatte bo en behalwe die wetenskap wat in die klaskamer onderrig word. Leerders het belangstelling in wetenskaplike vraagstukke en ontwikkelings getoon, maar het aangedui dat hulle nie ingelig is oor sodanige vraagstukke en ontwikkelings nie. Die resultate van betekenisvolle verskille het getoon dat die wetenskapservaringe buite die skool, belangstellingsvlakke en die mate van ingeligtheid van manlike en vroulike graad 11-leerders verskil het.

Hierdie navorsing het implikasies nie net vir die diegene wat wetenskapkurrikulums beplan en ontwerp nie, maar ook vir wetenskapopvoeders en vir verdere navorsing ten opsigte van openbare begrip van wetenskap.

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List of acronyms

ANOVA	Analysis of Variance
FRD	Foundation for Research and Development
NSF	National Science Foundation
PUS	Public Understanding of Science
PUSET	Public Understanding of Science, Engineering and Technology
S & T	Science and Technology
STS	Science / Technology/ Society

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The Science and Technology Committee Report of Science Education (2002) has lamented that there is increasing concern across the United Kingdom that pupils are bored with science, particularly science post-16. A similar observation has been made in Japan. The National Institute for Educational Research (2000) has noted with concern youth's disinterest in Science and Technology, particularly physical science. This report indicates that there is a tendency that students' interest in physical science diminishes as they advance in grade.

A study on the pupils' and parents' views of the post-16 school science curriculum has attributed this boredom and disinterest to a science curriculum framework that is obscure and irrelevant to contemporary needs. Science is seen as dominated by content, with hardly any connections with pupils' everyday lives, contemporary science or socio-scientific issues (Osborne & Collins, 2000:5-7).
The lack of opportunity for creativity in school science has also been identified as contributing to this growing disinterest in science. Disinterest can also be attributed to lack of knowledge and experience with the day-to-day activities of

people in the Science and Technology professions, particularly those relating to physical science and engineering.

The view expressed by teachers is that school science curriculum and approaches to teaching science required radical change, if pupils were to gain an understanding of science-related issues (Osborne & Collins, 2000:78).
In his own words Partridge (2003:56) has proposed science experiences out of the classroom as a remedy to this problem, in the following way:

" a reappraisal of the role of practical experiences in science education, both in and out of the classroom, might reintroduce some sparkle to the subject".

Similarly, the Science and Technology Committee Report of Science Education (2002) has suggested that the answer to recaptivating students' interest in, and enthusiasm for, science inside the classroom may lie in scientific experiences outside the classroom.

This background information about the state of Science and Technology education in developed countries sets the scene against which the scientific experiences of Grade 11 learners are investigated in a particular South African context, marked by underdevelopment. The choice of Grade 11 learners as the target group for this research is based on the fact that Grade 11 learners have an average age of sixteen years. Thus, the state of these learners with regard to their interests and public understanding and involvement with science can be compared to those of the countries described above.

This research seeks to describe the scientific experiences of both male and female Grade 11 learners in rural schools in Butterworth, and the extent to which the scientific experiences of these learners indicate their interests, public understanding and engagement with science.

1.2 RATIONALE FOR THE STUDY

My interest in the topic arose out of my involvement with science teaching in a rural high school, for Grade 10-12. I have observed that there is a tendency that learners' interest in science diminishes as they advance in grade. This resulted in the drop in the percentage pass rate for science and reluctance on the part of the learners to enroll for science. The majority of those who dare to enroll would rather have it on a standard grade level rather than write it on a higher grade. My other observation is that science education at high school level tends to focus more on concepts, principles, laws, theories and formulae with very little reference to science-related public issues as, for example health, environment, energy, food, space et cetera.

My other reason for carrying out this research is based on my assessment of current scholarship in the field of public understanding of science and the scientific experiences of learners. I have found that there is limited research in South Africa, on the out of school scientific experiences and public understanding of science by high school learners. Most studies have focused on the learners' general knowledge of scientific facts and attitudes towards science and technology (Foundation for Research and Development, 1996).

It is against this background that this research seeks to describe students' scientific experiences not only as indicators of their public engagement with Science and technology issues but also, how these experiences influence their interests and motivation to learn Science and Technology.

Osborne (1998) has observed that science education is distinguished by the virtual absence of any treatment of contemporary science or scientific controversy, leaving young people ill-prepared to understand and interpret the science that permeates the media, and lacking any equivocal understanding of science as a social practice. This is contrary to the emerging significance of scientific topics on the public through such issues as global warming, ozone depletion, food safety and the genetic modification of organisms which have demanded that science education pay more attention to its role in developing a scientifically literate public (Osborne & Collins, 2000:9).

This survey was carried out on the scientific experiences of Grade 11 learners, to establish and describe the extent to which the said learners are sensitized to the possibilities of Science and Technology, through acts of participation in activities and debates about Science and Technology issues. The findings not only highlight the need to frame and focus the impact of these out-of-school scientific experiences on the scientific literacy of Grade 11 learners or public understanding of science by Grade 11 learners but, they also highlight the need to integrate out-of-school scientific experiences with the classroom teaching and learning of S&T. Science and Technology needs to be lived and experienced by the learners.

The study also aimed at establishing whether factors such as gender, location of the school account for variations (differences) on the scientific experiences and public engagement with S&T issues and debates, of grade 11 learners.

The findings of this research will inform curriculum specialists about:

- The need to develop a curriculum that will foster public understanding of science necessary for everyday life.
- The need to develop a curriculum that will foster the public appreciation of science.
- The need to develop a curriculum that will improve the public understanding of science (Osborne, 1999).

1.3 RESEARCH PROBLEM AND OBJECTIVES

The following research questions are addressed by the study:

i. To what extent are the public scientific experiences of Grade 11 learners an indicator of their participation and public engagement with issues and debates in the fields of Science and Technology?

ii. Are there any variations or differences between male and female Grade 11 learners' scientific experiences and public engagement with issues, debates and activities in the fields of Science and Technology?

iii. Are there any variations or differences in the level of interest and being informed about Science and Technology issues, of male and female Grade 11 learners?

The following were the objectives of this research:

i. To describe the public scientific experiences of Grade 11 learners as indicators of their interests, participation and engagement with Science and Technology beyond classroom settings.

ii. Further, to then classify Grade 11 learners as an attentive, interested and residual public on the basis of their public scientific interests and knowledge.

iii. To provide subject teachers, advisors and curriculum specialists with the information that they can use to plan the necessary interventions that would promote public understanding of Science and Technology, engagement and participation in Science and Technology activities and debates about science issues.

1.4 RESEARCH APPROACH

The survey research method was used to collect data. The statements relating to the out of school scientific experiences of learners, and the level of interest and being well informed about scientific issues, were derived from literature on the scientific literacy and public understanding and engagement of learners with science. The response data from the stratified sample of 250 learners from five (5) schools located both in rural of the Butterworth district were collected personally by the researcher, in some cases through the science teacher and in other instances through an accomplice teacher. However, the criterion used in the selection of schools for inclusion in the sample was willingness of schools to cooperate and collaborate with the researcher in the study.

Descriptive statistics (frequencies, means and standard deviations) were used to analyse patterns of quantitative responses in the data. ANOVA was used to determine differences or variations in the means of male and female learners (MacMillan & Schumacher, 1993). The responses were coded, recorded using standard personal computer software (Statistica). This raw data was used to perform the following tasks:

- The distribution of responses for each question and which helped to postulate reasons for the spread of data in the subsequent analysis.
- Graphic profiles of responses of each of the categories were used to indicate the spread and variation of responses to the various aspects of the out of school scientific experiences and public understanding of science.

1.5 LIMITATIONS OF THE RESEARCH

i. Survey data are sometimes very sample-and context-specific.

ii. Surveys may lack depth and an insider perspective and thus may lead to a 'surface level' analysis.

1.6 OUTLINE OF CHAPTERS

Chapter 1 develops the idea for the thesis and motivation for the study. The overall aims of the study are illuminated and magnified through articulation of research questions. A rough indication of the design, plan and the methodology followed in addressing the research problem is indicated.

Chapter 2 elaborates on the theoretical background of the problem, and summarises available literature on public understanding and engagement in Science & Technology and scientific experiences in relation to a particular public namely, science education community. Differences in terms of the geographic location of learners and gender are also sought.

Chapter 3 describes the research methodology in detail. The methodological aspects described in this chapter are: the development of the instrument; the survey research method; samples and their contents; procedures for data collection; data capture and analysis; selection of statistical methods.

Chapter 4 consists of the presentation and summary of the quantitative results using tables and other visual devices (graphs, figures, tables). Emerging trends and patterns in the data are identified with reference to the research questions and the objectives. The empirical research findings are discussed and conclusions drawn. Results from the previous chapters are integrated and collated with the empirical findings to justify and account for their occurrence. Anomalies and /or deviations in the data are discussed as well.

Chapter 5 discusses the larger significance of the data and the implications that they might have for the curriculum specialists, science educators, science educational programmes and further research.

At the end of this study, I will provide references and appendices to aid understanding of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 DEMARCATING THE LITERATURE COVERED

This chapter is a discussion of the literature covered and also how the researcher has decided to demarcate the scholarship to be included in the review of literature. The literature studied is organized around the research questions and objectives addressed by the study, namely: public scientific experiences of Grade 11 learners as indicators of their interests, public understanding and engagement with issues and debates in the fields of Science and Technology; variations or differences between male and female Grade 11 learners' interests, scientific experiences and public understanding and engagement with issues, debates and activities in the fields of Science and Technology.

The study of scientific experiences as indicators of interest, understanding and engagement with science forms the basis of a conceptual framework used in this empirical study to develop the questionnaire for data collection and the interpretation of the findings.

The study of the out-of- school scientific experiences of learners is informed by international and local literature on "public understanding of science" or "scientific literacy" literature. The former phrase is commonly used in Britain while the latter is used in the United States (Laugksch, 2000:17). Thus, the two concepts are used interchangeably in the study and should be understood to mean the same thing. This body of literature not only concerns itself with what the general public ought to know about science but also, and more importantly for the purposes of this research, deals with everything to do with science education, namely:

- Comprehensiveness in the purposes of science teaching in the schools.
- Social and cultural relevance of science in a scientific and technological society.
- Science education reforms with "scientific literacy" or "public understanding of science" as policy goals relating science education.

(Atkin & Helm, 1993)

The premise from which this literature study departs is that Science and Technology needs to be lived and experienced by learners. Thus, the need to integrate public scientific experiences with the teaching and learning of Science and Technology is highlighted in this study.

2.2 CONCEPTUAL DEFINITION OF PUBLIC UNDERSTANDING OF SCIENCE OR SCIENTIFIC LITERACY

There is general agreement among science educators that general scientific literacy should be an important outcome of schooling (Roth & Lee, 2001). However, a number of different positions as well as interpretations of scientific literacy have been proposed. Some of these interpretations were based on research, and others were based on personal perceptions about the characteristics of a scientifically literate individual and what such an individual should be able to do. Roth and Lee (2001) maintain that studies in scientific literacy have tended to focus on:

- how individuals can be made to internalise or construct specific scientific concepts
- what science content to teach
- how to make students transfer science to out-of-school situations

These authors however, decenter the focus from these trends to consider the following assumptions:

- science as one of the many resources that people can draw on in everyday collective decision-making processes.
- students learn by participating in activities that are meaningful because they contribute to their community as a whole.

They therefore think about 'scientific literacy' in terms of a form of science that relates in reflexive ways to the concerns, interests and activities of citizens as they go about their everyday business (Roth & Lee, 2001:3).

Pella et al (1996) cited by Laugksch (2000:76) concluded that the scientifically literate individual was characterized as one with an understanding of the following among others:

- interrelationships of science and society
- ethics that control the scientist in his work
- nature of science

Similarly, Miller (1993) defines scientific literacy as consisting of three dimensions, namely:

- an understanding of the norms and methods of science (nature of science)
- an understanding of key scientific terms and concepts (science content knowledge)
- an awareness and understanding of the impact of Science and Technology in society.

Shen (1975) in Laugksch (2000:77) has suggested three categories of scientific literacy, namely practical, civic and cultural scientific literacy. *Practical* scientific literacy entails possession of scientific knowledge that can be used to help solve practical problems related to food, health and shelter. *Civic* scientific literacy relates to scientific knowledge and understanding that would enable citizens to become sufficiently aware of science and science-related public issues in order to be involved in the decision-making process related to such issues as, for example health, energy, natural resources, food and the environment. Shen (1975) asserts that *cultural* scientific literacy is important for opinion leaders and decision makers. However, he points out that this category is achieved by a small number of individuals who form part of the intellectual community.

This relationship between science and public understanding is taken further and advanced by researchers such as Hazen and Trefil (1991) and Hirsch (1987). They define scientific literacy as the knowledge one needs to understand public issues. They argue that this knowledge is important in national communication, such as, for example, reading newspapers and magazines, communicating with elected representatives, or following debates about public issues. They believe that scientifically literate individuals should be able to place news of the day about science in a meaningful context (Laugksch, 2000:80).

Shamos (1995) and Ziman (1991) contend that scientific knowledge comes as part of life among people with interests in a real world. This functionalist view of scientific literacy accentuate meanings and social uses which science has for members of the public and also that members of the public are not passive consumers of science but that scientific knowledge finds meaning and appreciation when put in a social context. This view contends that the public has the need for, and use, scientific knowledge in a wide variety of social contexts that affect their personal or economic well being (e.g. nutrition, health, energy usage) (Jenkins, 1994). Similarly, Miller (1983) defines scientific literacy in terms of effective functioning of an individual in society.

Therefore, the conclusion can be drawn that it is the extent of involvement in and with society that measures an individual's public understanding and engagement with Science and Technology. Thus, the functionalist notion of public understanding of science or scientific literacy accentuates the diffusion of minimal knowledge, skills and values among the public so as to fulfill a particular role in society (Laugksch, 2000:83).

2.3 INTEREST GROUPS CONCERNED WITH PUBLIC UNDERSTANDING OF SCIENCE OR SCIENTIFIC LITERACY

Laugksch (2000:74) identifies a number of different factors that can influence interpretations of scientific literacy and public understanding of science. These factors include the number of interest groups that are concerned with scientific literacy, different purposes for advocating scientific literacy and different ways of measuring it. The categories of "interest groups" are characterized by a common goal of promoting scientific literacy in the whole or in a particular section of the wider community. These interest groups differ with respect to the "audiences" that form the focus of the groups' attention (Laugksch, 2000:76).

The interest group relevant for the purposes of this research can be identified as the *science education community*. This community is concerned with the goals of science education; how skills, values and attitudes implied by the goals are successfully incorporated into the science curriculum. It includes science curriculum specialists, as well as professional science education associations. This group has as its focus primary, secondary and tertiary school education. This research has as its target secondary school learners in Grade 11. Thus, the science education community is concerned with the relationship between formal education and public understanding of science.

The second interest group includes *social scientists and public opinion researchers* concerned with Science and Technology policy issues. This group concerns itself with the extent of the general public's support for Science and Technology, as well as the public's participation in Science and Technology policy activities. Activities of this group include measuring the public's attitude towards science and technology in general and towards selected current policy issues in particular (Laugksch, 2000:75).

The third interest group includes *sociologists of science*. They are concerned with the legitimation and certification of scientific knowledge. Research activities of this group include inquiry on how individuals in everyday life interpret and negotiate scientific knowledge; how expert knowledge needs qualifying before it can be used in a particular situation (Laugksch, 2000).

The fourth interest group can be identified as the *informal and non-formal science education community*, and those involved in general science communication. This group consists of professionals who report science as news and write about science in general. These professionals include relevant personnel involved in museums and science centers, botanical gardens and zoos and those involved in science exhibitions and science displays. Personnel involved in science radio programmes and television shows also constitute this interest group (Laugksch, 2000:75).

The National Science Survey (2002) classifies the audiences for Science and Technology issues into three groups on the basis of their interests and being well informed about an issue, namely: the attentive public, interested public and residual public. The *attentive public* consists of those who express a high level of interest in a particular issue; feel very well informed about the issue; and read a newspaper on a daily basis, read a weekly or monthly magazine or read a magazine relevant to the issue. The *interested public* consists of those who claim to have a high level of interest in a particular issue but do not feel very well informed about it. The *residual public* consists of those who are neither interested in nor feel very well informed about a particular issue. This analytic frame is also used in this investigation to describe grade 11 learners' level of interest and being informed about scientific issues.

Since science is a public good, with a variety of publics interested and engaged with it, the following section argues for the synergy between public scientific experiences and the science curriculum.

2.4 SCIENTIFIC EXPERIENCES AND THE SCIENCE CURRICULUM

The question as to whether the science curriculum should harness and include the scientific experiences of learners can be answered by looking at the underlying rationale of the curriculum and its subject matter (Hu et al, 2003:171). The rationale consists of the underlying assumptions, beliefs, principles, or ideologies, which direct the goals, shape the forms, and determine the subject matter of education.

The subject matter comprises the teaching substance in the classroom, which is used to meet the reasons for education (Hu et al, 2003:171).

With regard to the rationale underlying the science curriculum, Eisner and Vallance (1974) cited in (Hu et al, 2003) has identified five general orientations in relation to the curriculum, namely:

- development of cognitive processes
- curriculum as technology
- self actualization or the curriculum as a complete experience
- social reconstruction-relevance
- academic orientation

The orientation of the social reconstruction-relevance seeks to develop a better "fit" between the individual and society. The point is that science content should carry social and daily relevance. This orientation therefore, highlights the need for the science curriculum that has connections with pupils' everyday lives so that they can appreciate science as a public good.

With regard to the science curriculum's subject matter, three aspects of the understanding of science that can be conveyed include:

- conceptual science content
- method of inquiry used in science
- science as a social enterprise

The extent to which there is synergy and integration between these three aspects in the conveyance of the science curriculum will determine the extent to which public understanding of science is improved. In her theory of the multiple contents of the public understanding of science, Solomon's (1998) conceptual model for improving the teaching and learning of science calls for a science curriculum that not only concerns itself with the personal development of the individual, but also with the humanistic utility of science for societies' needs with specific reference to health, environment social reconstruction, ethical dilemmas et cetera. In a study of high school students' preferences of curriculum components to be included in the science curriculum in Taiwan, it was found that senior high school students favoured social-ethical issues in addition to scientific concepts, manipulative skills and application of science. Even though history of science was least preferred, Hu et al (2003:175) argue for its inclusion in the science curriculum to avoid the emergence of a gap between social sciences and natural sciences. The findings outlined above highlight the need for a science curriculum that includes the social context and the social responsibility of science.

Similarly, the value of school science for an understanding of socio-scientific issues was highlighted by parents' views of the school science curriculum in the following way:

- school science should provide children with the tools to support an understanding of science and its role in society.
- school science should play an important role in enabling young people to adopt a 'questioning approach' to scientific advances.
- school science to should encourage young people to adopt a 'critical view' of the reporting of science in the media.

(Osborne & Collins, 2000:99)

Outside the school scientific experiences and socio-scientific issues are features of a school science curriculum that are enduring and leave a positive affective residue. Osborne and Collins (2000: 116) maintain that school science is remembered positively when it makes contact with the contemporary events of the age be it space exploration or the blast furnaces of the 1960s, or the global warming and cloning of today. These scholars maintain that removing such events or diminishing the opportunity for such experiences, has a high cost for pupils' affective experience of the subject. This explains why there are reports of boredom and disinterest with school science among learners.

Roth and Lee (2001:1) maintains that the needs of diverse groups of people – except white middle-class males – have not been met, leading to their exclusion from science. It is against this background that the following section deals with gender differences in the public understanding of science.

2.5 GENDER DIFFERENCES IN PUBLIC UNDERSTANDING OF SCIENCE AND INTEREST IN SCIENCE

Gough (2003) maintains that interest arousal is associated with the nature and orientation of the subject matter that is taught or learned. She goes on to mention four motivational traits related to students' preferences for particular types of learning activity, based on the predominance in the learner of one of the following needs:

- The need to achieve (achiever students)
- The need to satisfy one's curiosity (curious students)
- The need to discharge a duty (conscientious students)
- The need to affiliate with other people (sociable students)

Sadly though, it is a fact that science teaching and learning as it is, does not accommodate conscientious and sociable students. Roth and Lee (2001) have observed that the poor, people of colour, and women may fail in school science because of the nature of science practices and forms of knowing that are stressed in teaching. These authors conclude that science discourages women because its ways of knowing and everyday practices priviledge white middle-class and male standpoints.

Experience and relationships with others also explain gender differences in interests, public understanding and engagement with science. In a study conducted by Jones et al (2000:182), girls reported having different out-of-school experiences in science than their male peers, with males reporting more extra-curricular experiences. Meador (1999) argues that girls lose out because boys have prior hands-on experiences with the physical phenomena. However, girls attributed their positive attitude towards science, in part, to extracurricular experiences such as doing science at home, reading about science, or watching science-related television shows. They also reported that the science experience they had with other people they loved or admired impacted on their acceptance of science as a career option.

Meador (1999:9) cites teacher bias that is resistant as accounting for this gender bias in science. Practicing teachers are reported as having difficulty in identifying subtle but pervasive gender bias. Meador (1999:11) maintains that the assumption that cognitive differences account for girls' lower performance in sciences is incorrect, as studies have shown that boys and girls have similar cognitive abilities. The incorporation of public scientific issues and debates in the curriculum should not be underestimated as one way of addressing gender bias and promoting interest and public understanding and engagement with Science and Technology.

Hue et al (2003:175) have observed that boys and girls favour different curriculum components. Whereas boys are willing to engage in problem solving activities related to science and to learn the development of science, girls prefer to put more effort into learning scientific concepts, discussing social issues related to science, and knowing things related to the application of science. These authors are quick to point out that the content of the science curriculum is a poor reflection of female interests and that the early phase of high school education should provide sufficient aspects of science. One of the strategies proposed by these scholars to create a gender-inclusive science education and to promote interest and public understanding and engagement with science is based on the concept of 'science for all' and 'science education for scientific literacy' which seek to incorporate the preferences of students with regard to the curriculum components that interest them the most, and expose students to public scientific activities.

The Science/Technology/Society (STS) curriculum developed and championed by the National Teachers Associations in the USA is an attempt to include scientific issues in the curriculum and give prominence to the issue of gender equity in America's public schools. STS uses current issues as the foundation of study, with a problem-solving format that introduces new concepts and terminology on a need-to-know basis. It involves extensive co-operative work, and relies upon more authentic experimentation and research by students than traditional textbooks and their cookbook labs.

Weld (1999) cited by Meador (1999:12) has noted that girls who experience a STS approach are far more likely to regard science class as fun, that it boosts girls' achievement levels and positive attitudes towards science, and girls perform as well as or better than boys on content exams after an STS programmes.

Meador (1999) maintains that improving teachers' interactions with students can reduce gender bias in science and help improve public understanding and engagement with Science and Technology. He maintains that teachers can do this by connecting science to other subjects and the real world, by choosing metaphors and examples which avoid stereotypes and draw upon common experiences, by fostering true collaboration and not allowing boys to dominate, by providing girls with extra opportunities to use technology and other tools, and by giving greater emphasis to verbal strength where girls often excel.

2.6 CONCLUSION

The discussion of public understanding and engagement with science, scientific experiences and the science curriculum has provided an invaluable insight on the factors that account for boredom and disinterest in science. The discussion on the out of school scientific experiences has pointed out that interest and curiosity can be rekindled when classroom science is linked with socio-scientific issues and debates that permeate the media and everyday life activities of the learners. Therefore, the synergy between school science, contemporary and public science was advocated.

Owing to gender differences in public understanding of science, interest and engagement with science, the literature reviewed has motivated the need for a science curriculum that caters for all learners with diverse preferences, learning styles and motivational traits.

Chapter 3 outlines the methodology and field practice procedures followed when conducting this research.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 SURVEY RESEARCH DESIGN AND SAMPLING DESIGN

Survey Research

Survey research was used in this investigation because it provides a broad overview of a large population and is able to elicit information that goes beyond mere description of patterns. Most studies in the field of "scientific literacy" or "public understanding of science" have made use of surveys because of their potential to generalise to large populations (Foundation for Research and Development, 1996; Jones et al, 2000; National Science Foundation Report, 2002).

Sampling Design

The sample consisted of five (5) rural high schools in the Butterworth district, with a total of five hundred (250) learners as respondents. The sampling technique used for the selection of schools to be included in the survey was stratified sampling with geographic location of schools as a sorting variable. Babbie and Mouton (2001) maintain that stratification by geographic location increases representativeness in social class, ethnicity as well as in a broad range of beliefs, interests, attitudes and aspirations. Stratified sampling was used since Butterworth has rural, urban, suburban and informal settlements.

However, it became impossible or unfeasible to select schools randomly from the rural stratum, as some schools selected were not willing to cooperate and collaborate with the researcher. Therefore, the sample had to involve whatever schools were available in the rural strata on the basis of their willingness to participate. The limitation imposed by this exercise is that generalisability of the findings is limited to the characteristics of the subjects in the rural areas of the Butterworth district and may not hold for other districts nor for other settlements in Butterworth (Babbie & Mouton, 2001; MacMillan & Schumacher, 1993).

3.2 QUESTIONNAIRE DESIGN

A closed questionnaire using statements and fixed format responses was compiled for the following reasons:

- Respondents' lack of time had been identified as a factor that might affect response rates, and carefully worded statements with fixed format responses were considered to be less arduous than formulating and writing replies to open-ended questions.
- Carefully worded statements give respondents some insight into the issues that would have to be addressed by the research. Thus, the closed

questionnaire format was therefore thought to be less threatening than asking open-ended questions.

- A closed questionnaire can be more easily coded for quantitative computer data analysis than an open-ended questionnaire.

An attempt was made to formulate statements such that they each deal with the scientific experiences of the learners as indicators of their interests, understanding and engagement with public scientific issues. Besides individual statements about the scientific experiences of the learners and the extent of their engagement with science, questions about their level of interest and being informed about scientific issues were modified and adapted from the National Science Foundation survey (National Science Foundation, 2002), to suit this particular science public (learners) in the South African context. The questionnaire was designed using technical directives from Babbie & Mouton, 2001; MacMillan & Schumacher, 1993.

3.3 VALIDATION OF THE QUESTIONNAIRE

The first questionnaire compiled (draft copy) was given to a science educator and a senior educationalist who is familiar with questionnaires used in educational research. They were asked to comment on the validity of the statements and to suggest improvements with respect to the following:

- The accuracy and clarity of statements
- The appropriateness of the statements for scientific experiences and public understanding of science.
- Appropriateness of response categories
- Apparent duplication
- Subdivision of the questionnaire into sections

A great deal of attention was given to the layout, the order of the questions and to variety in the style of questioning and response categories in order to maintain interest and encourage respondents to complete the task.

3.4 COMPOSITION OF THE QUESTIONNAIRE

The final questionnaire (Appendix 1) is composed of three sections. Each section has a heading with a brief instruction. These point to a change in approach and ensure that respondents transit with ease from section to section.

Section 1

Section 1 of the questionnaire consists of four questions of a general and personal nature. These questions introduce the participant in a non-threatening manner so that the respondents feel they will be able to deal with the questions. Included in this section are the questions on gender, geographic location of the school, age and subjects enrolled for at school. These questions are used in the final analysis in combination with other results to indicate significant differences among the respondents.

Section 2

This section consists of ten statements related to the extent of the learner's scientific experiences and engagement with public science. It attempts to establish learners' involvement with science that permeates the public. Learners' responses statements can be used to infer the extent to which school science enables them to understand and engage with public science and also, the extent to which school science affords them the opportunity to engage with public scientific issues and debates.

Section 3

This section describes the learners' level of interest and being well informed about scientific issues. It consist of seven statements, which reveal areas in science fraught with interesting issues, debates, controversies et cetera. They include development of new technologies, inventions, medical discoveries, environmental pollution, space exploration, information technologies, biotechnology and genetically engineered foods. These questions are used in the final analysis to classify learners as attentive, interested or residual public.

3.5 STRUCTURE AND WORDING OF QUESTIONS

The statements were formulated, edited and reworded many times in an attempt to avoid double-barrelled and ambiguous statements and negative items. An attempt was made to direct the statements at specific factors and generalization was avoided as much as possible. The advice of practitioners such as Babbie and Mouton, 2001; Bailey, 1987; MacMillan and Schumacher, 1993; were followed as closely as possible.

An attempt was made to convey meanings and concepts to the respondents in short sentences. Thus, longer sentences were avoided and an attempt was made to avoid sentences involving subclauses. A personal tone was included in each question so as to make them more comfortable with the subject. All the unnecessary words were eliminated and simple words with many syllables, wherever possible, taking care not to change the overall meaning of the statement.

3.6 RESPONSE CATEGORIES

The questionnaire (appendix 1) comprises twenty-one statements in three different sections with variations in the types of response categories. The idea with variations has been to introduce variety and maintain interest. Therefore, different ordinal scales have been used for registering responses.

In section 2 a four-point scale is used to elicit the extent of scientific experiences and engagement with science in each of the statements relating to scientific experiences presented. A response category starting from negative to positive with responses ranging from *never* to *more often* are used in this section.

In section 3 a three-point scale is used to indicate the level of interest and being informed about scientific issues. Response categories range from *high level of interest and well informed; high level of interest but not well informed; neither interested nor informed.*

3.7 DATA COLLECTION AND FIELD PRACTICE

The questionnaires were administered during the normal school days in August-September 2003. The researcher and the science teacher in the school would distribute the questionnaires to the learners, and then collect the completed questionnaires. Some items in the questionnaire had to be explained by the researcher, especially those items on the level of interest and being well informed about scientific issues, owing to learners' not being conversant about such topics as biotechnology and genetic engineering.

Two hundred and fifty questionnaires were distributed in five high schools for the Grade 11 learners to complete but only two hundred and twenty five questionnaires were returned. Thus, the final return was 225 out of 250, a 90% response rate. The data gathered was considered to be sufficient to provide an adequate indication of the out of school scientific experiences, levels of interest and being informed about scientific issues of Grade 11 learners, at least for the rural schools in the Butterworth district. It was therefore considered unnecessary to send out more questionnaires to additional schools. A very low percentage of omitted responses occurred.

3.8 DATA CAPTURING AND DATA ANALYSIS

Quantitative Data

The questionnaire for this survey designed with a view to using a quantitative analysis to aid the investigation. Quantitative analysis can provide objective information as to the differences in the scientific experiences, interests and public understanding of science between rural and urban Grade 11 learners, and also between male and female Grade 11 learners. The statements on the questionnaire were each given a code number and these codes were used to denote each question in the subsequent analysis. The responses to the statements were coded using an ordinal scale, while the biographical data was coded using both nominal and ordinal scales. Failure to respond to a statement was recorded as 0 and was treated as no category in the subsequent analysis.

The responses were coded, recorded using standard personal computer software (Statistica). This raw data was used to perform the following tasks:

- The distribution of responses for each question was generated and recorded. This enabled the establishment of patterns of responses, and helped the postulation of reasons for the spread of data in the subsequent analysis.
- Graphical profiles of responses for each of the statements were generated to give an indication of the spread of the extent learners' scientific experiences, understanding and engagement with science.

This forms the basis for the presentation of findings and results.

Selection of Statistical Methods

In the next chapter descriptive statistics (frequencies, means and standard deviations) were used to describe Grade 11 learners' scientific experiences, interests, public understanding and engagement with science.

In this investigation, ANOVA was used to determine significant differences among the means of grade 11 learners in rural schools and urban schools and also, between male and female Grade 11 learners (MacMillan & Schumacher, 1993:346). A matrix is yielded where asterisks indicate significantly different group means. The standard alpha level of 0.05 was used.

3.9 CHAPTER SUMMARY

This chapter has presented and described the design and methodology followed during fieldwork. Issues of measurement such as formulation, compilation, development of the instrument, validation of the instrument are outlined. Details of the data collection process, including gaining access to the subjects, data collection techniques and procedures used and the times for data gathering are described. Data capturing and coding, including the rationale behind the selection of data analysis procedures as well as the actual procedures are described. Shortcomings, limitations and the quality of data collected are also described.

The results and findings of the research are presented in the following **chapter 4.**

CHAPTER 4

ANALYSIS AND DISCUSSION OF THE RESULTS

4.1 INTRODUCTION

The purpose of this particular research project was to describe the scientific experiences of Grade 11 learners as indicators of their interests, understanding and engagement with science issues and debates that permeate the public.

Statistical tests were computed to establish whether there were any significant differences between male and female Grade 11 learners' scientific experiences, interests, public understanding and engagement with science; and also significant differences between the scientific experiences, interests, understanding and engagement with science between learners in rural schools and urban schools.

In the following sections descriptive trends and patterns and results of significant differences are presented, discussed and conclusions drawn. Secondly, results are interpreted in terms of literature to show connections between results and literature reviewed.

Thirdly, anomalies and surprising results are discussed to show whether they confirm or deviate from the expectations. An attempt is made to provide reasons for their occurrence.

4.2 DESCRIPTIVE FINDINGS: OVERALL TRENDS

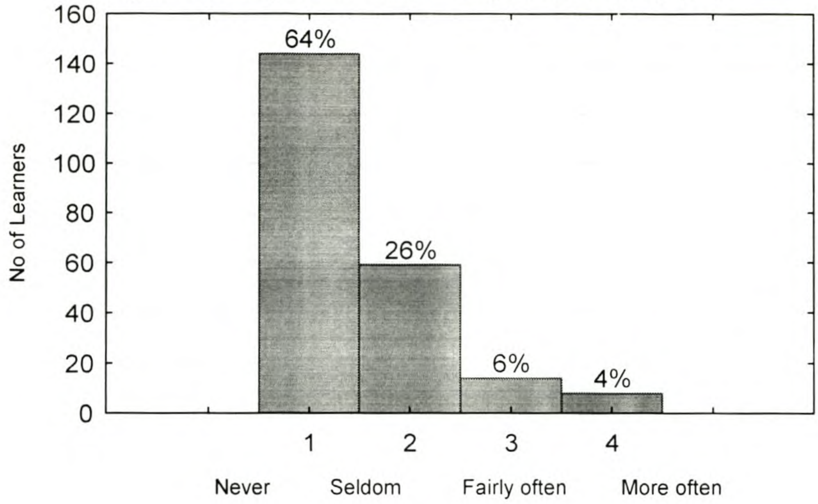
The purpose of these descriptive findings and overall trends was to provide a general survey to test the climate in both rural and urban schools in relation to the scientific experiences, interests, public understanding and engagement with science. Thus, Grade 11's responses (hereafter referred to as respondents) were analysed and interpreted.

4.2.1 *Scientific experiences of Grade 11 learners*

The descriptions of the patterns of responses of Grade 11 learners in each of the ten statements relating to their scientific experiences are presented.
Firstly, Grade 11 learners' responses to each of the items are analysed and documented using histograms to present the frequency of occurrence of each response category and the distribution of data.

A histogram of the distribution of responses for item 1 is presented in figure 1 below.

Figure 1: Reading science articles in magazines and newspapers

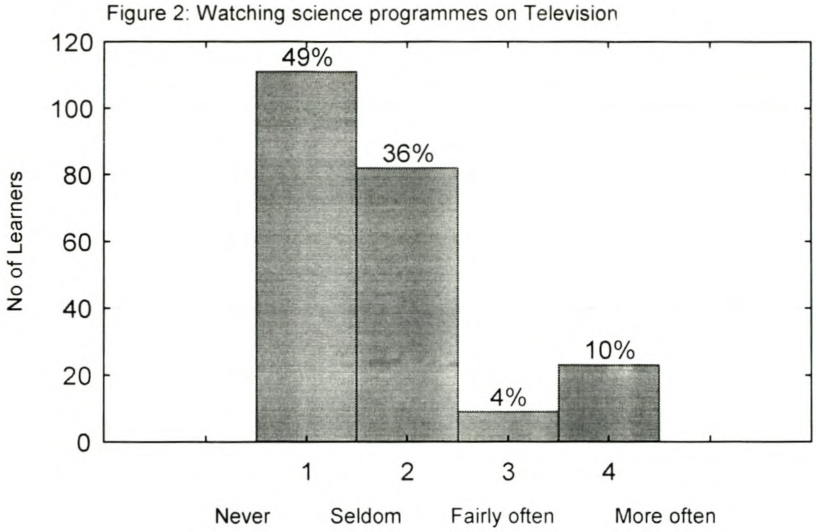


The respondents included male and female Grade 11 learners, with the largest percentage (64%) of the sample i.e., more than half, falling within (1) *never* and 26% percent reporting that they (2) *seldom* read science articles in magazines and newspapers. Only few learners reported that they read science articles in magazines and newspapers *fairly often* (6%) and *more often* (4%).

This result confirmed my observation and hunch of this research that Grade 11 science teaching and learning is not enabling and/or affording the learners the opportunity to engage with science that permeates the print media.

Figure 2 shows the distribution of responses for out-of-school scientific experience 2. The following results were obtained:

Figure 2: Watching science programmes on Television

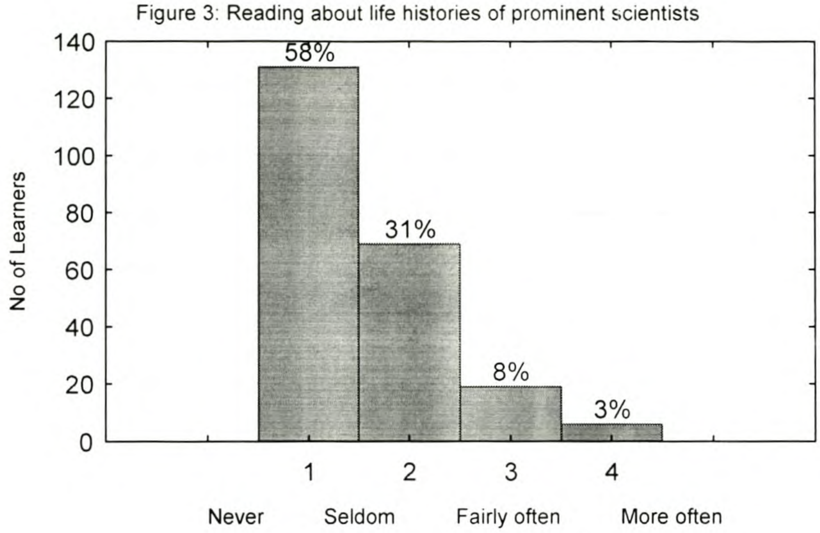


*Fourty n*ine percent of the respondents reported to have never watched science programmes on television while *thirty six* percent reported that they seldom watch science programmes. Only *four* percent watched science programmes fairly often compared to the *ten* percent who watch science programmes on TV more often.

Thus, a cumulative *fourteen* percent of the sample reported engagement with Science and Technology on television to supplement and enrich school science.

Figure 3 presents the distribution of responses for out-of-school scientific experience 3 on the questionnaire. The following results were obtained:

Figure 3: Reading about life histories of prominent scientists



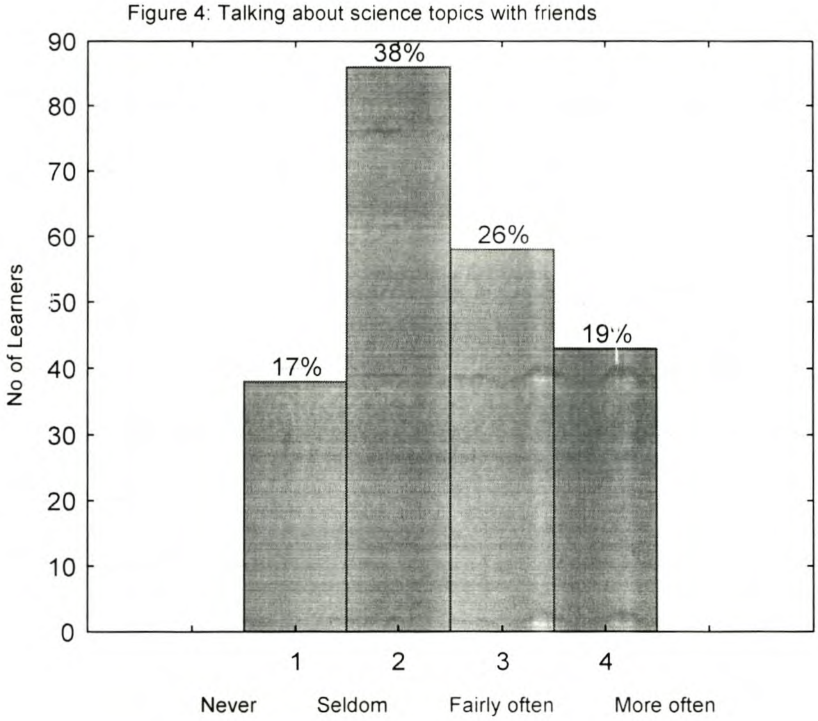
Fifty eight percent of the Grade 11 learners reported that they *never* read about the life histories of prominent scientists, whereas *thirty one* percent reported that they *seldom* read about life histories of scientists.

Eight percent indicated that they read about life histories of scientists *fairly often*, whereas *three* percent read about life histories of prominent scientists *more often*.

Cumulatively, only *eleven* percent of respondents are interested in understanding the life histories of scientists. This finding not only confirms my observation but also points to the need to include history of science themes in the school science curriculum. In fact, this finding finds support from Hu et al's (2003) research where learners expressed interest in the history of science and argued strongly for its inclusion in the science curriculum.

Figure 4 is a presentation of the distribution of responses for item 4 in the questionnaire on the scientific experiences of grade 11 learners. The following results were obtained:

Figure 4: Talking about science topics with friends

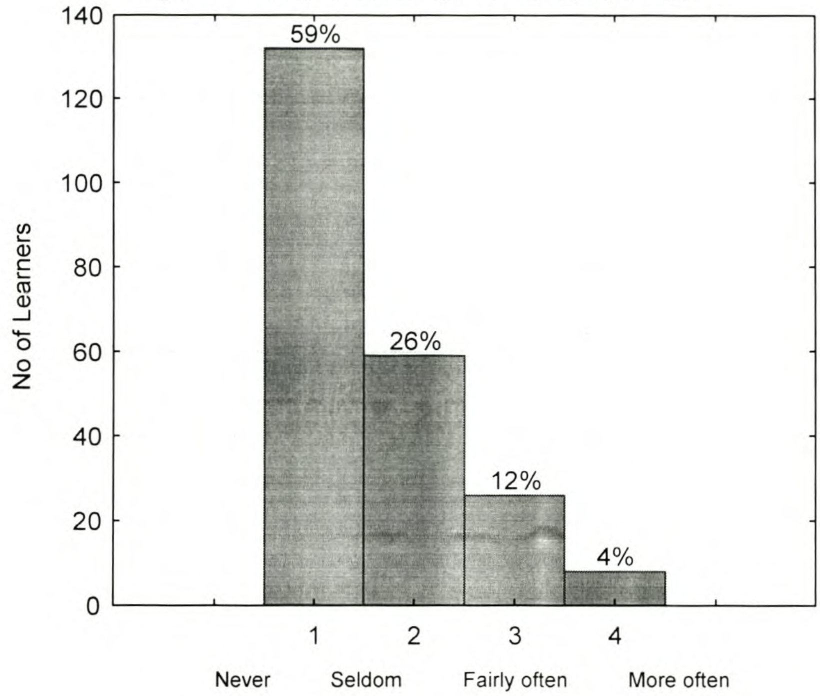


Even though most learners expressed involvement and engagement with this scientific experience, results indicate that *seventeen* percent of respondents *never* talk about science topics with friends. *Thirty eight* percent *seldom* talk about science topics whereas a cumulative *forty* five percent talk about science topics *fairly often* and *more often*.

These results attest to the need for involvement and engagement with Science and Technology on the part of the learners through discussions and debates about interesting science topics. Science teaching and learning should afford learners the opportunity to discuss and debate about interesting science topics.

Figure 5 is a presentation of the distribution of responses for item 5 on the scientific experiences of Grade 11 learners. The following results were obtained:

Figure 5: Listening to science reportson news programmes

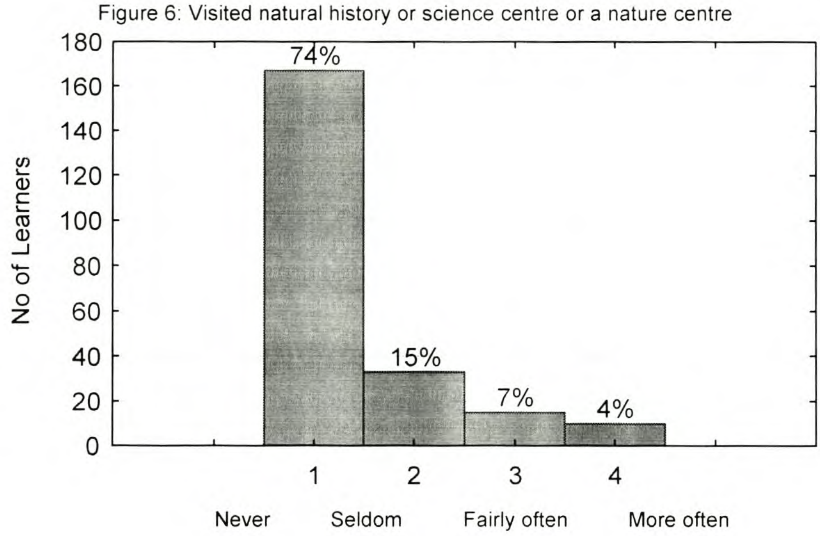


Most learners, *fifty nine percent* reported that they have *never* listened to science reports on news programmes, whereas *twenty six* percent reported that they *seldom* list to science reports. Cumulatively, only *sixteen percent* listen to science reports *fairly often* and on a *regular* basis.

Perhaps, this lack of involvement with science and technology that permeates this media can be explained by lack of knowledge about these scientific reports and news programmes or learners do not have access to such resources as radio and television owing to non-availability of these in most rural homes.

Figure 6 presents the distribution of responses for item 6 on the questionnaire on the out-of-school scientific experiences of Grade 11 learners. The following results were obtained:

Figure 6: Visited natural history or science centre or a nature centre



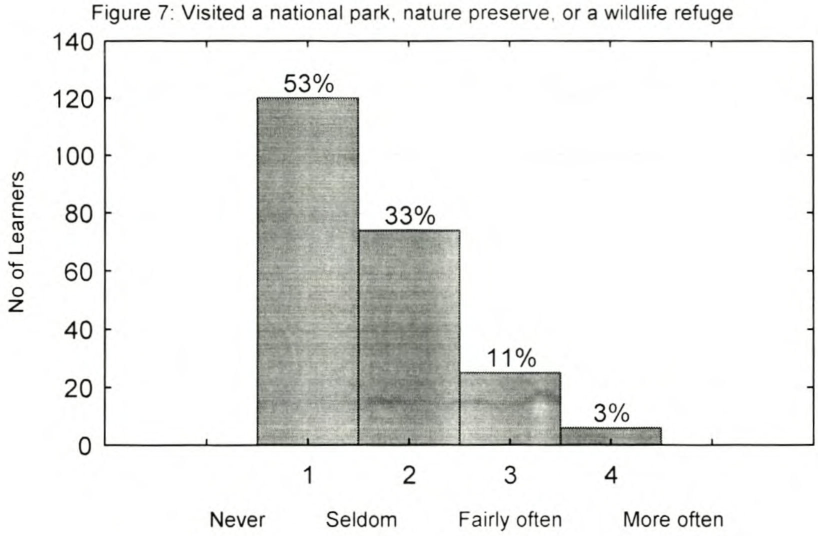
More than two-thirds (74%) of the learners reported to have *never* visited a natural history centre, science centre or a nature centre. Only *fifteen* percent *seldom* visits and a cumulative *eleven* percent of learners reported to have visited these centres *fairly often* and *more often*.

The importance of these centres for stimulation and kindling of curiosity, wonder and interest cannot be overemphasized. Perhaps, the diminishing interest and boredom alluded to in Chapter 1 can be explained by lack of visits to centres like these.

Therefore, this finding challenges science teachers to include science trips, excursions in their year plans.

Figure 7 is a presentation of the distribution of responses for item7 in the questionnaire on the out-of-school scientific experiences of Grade 11 learners. The following results were obtained:

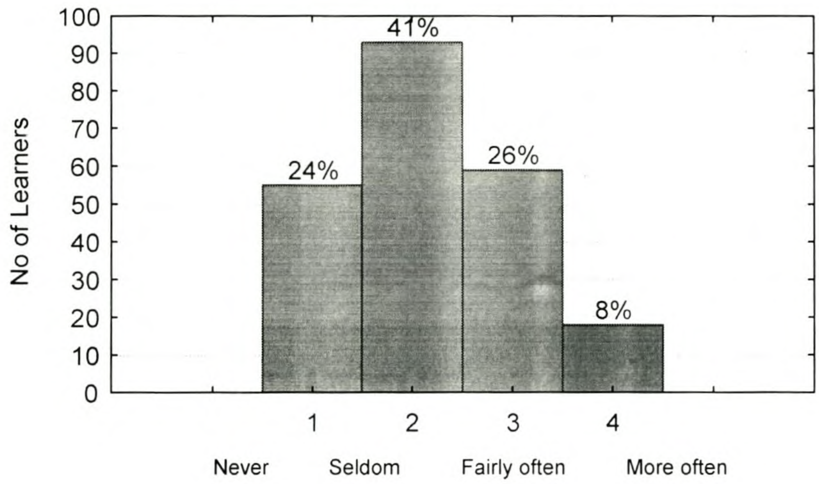
Figure 7: Visited a national park, nature preserve, or a wildlife refuge



More than half of the learners i.e., *fifty three* percent indicated that they have *never* visited a national park, nature preserve, or wildlife refuge. *Thirty three* percent indicated that they *seldom* visit these centres whereas a cumulative *fourteen percent* reported that they visit these centres *fairly often* and *more often*. Once again, this finding attest to the fact that science teachers in the rural schools do not afford learners the opportunity to visit centres like these, thereby robbing them the opportunity to experience science and thus making science interesting to the learners.

Figure 8 presents the distribution of responses for the scientific experience of taking something apart to see how it works:

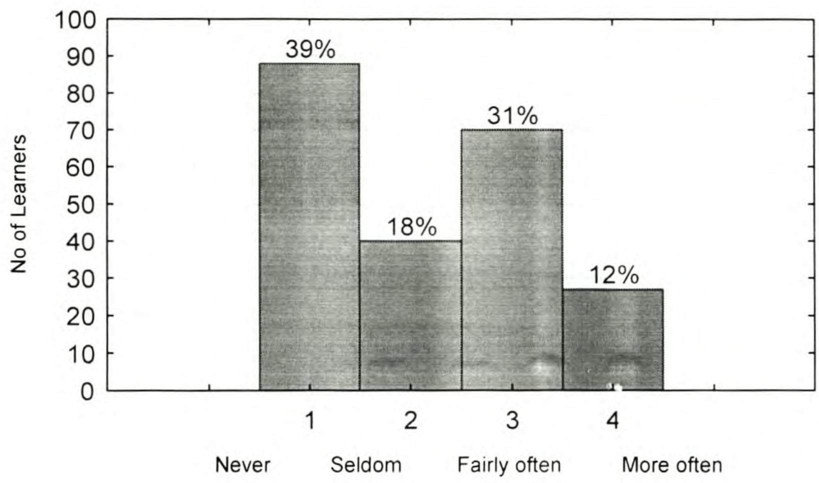
Figure 8: Taken something apart to see how it works



Responses varied with *forty one* percent of respondents reporting that they *seldom* engage themselves with this scientific experience. A cumulative *thirty four* percent of respondents reported involvement and engagement with this scientific experience *fairly often* and *more often*. *Twenty four* percent of the learners reported that they have *never* taken something apart to see how it works.

Figure 9 is a presentation of the distribution of responses for the scientific experience of fixing something mechanical or electrical:

Figure 9: Fixed something mechanical or electrical

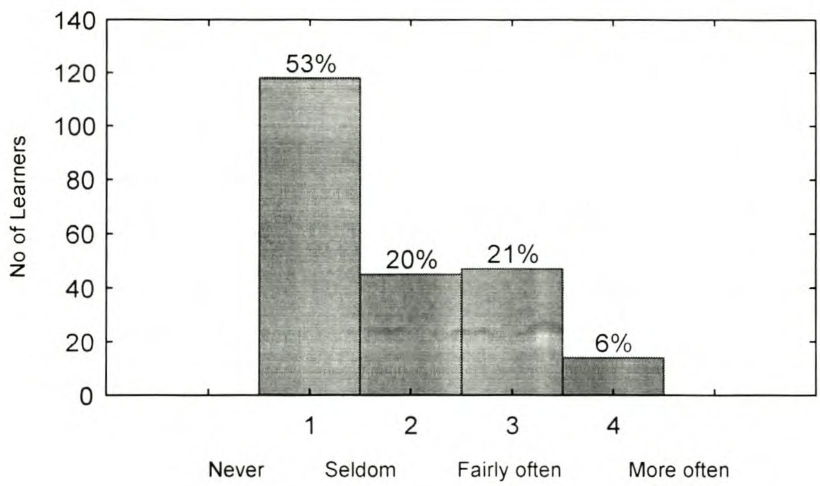


Even though a cumulative forty three percent of learners indicated involvement and engagement with this out-of-school scientific experience, thirty nine percent of respondents indicated that they have never had this scientific experience, whereas eighteen percent indicated that they seldom fix something mechanical or electrical.

This finding indicates that there is quite a significant number of learners who are engaged with this scientific experience. It would be interesting to look at the gender differences in so far as this experience is concerned in the analysis of variance, so that an argument can be made about gender bias in the scientific experiences of male and female learners.

In figure 10, the majority of the respondents, *fifty three* percent in the sample reported that they have *never* performed a chemical experiment or used a chemistry set. *Twenty percent* reported that they *seldom* perform chemical experiments and a cumulative *twenty seven* percent of respondents reported that they perform chemical experiments *fairly often* and *more often*.

Figure 10: Performed a chemical experiment or used a chemistry set



This result just shows that most learners experience science as something out of this world. It remains abstract, something to be imagined rather than to be experienced. No wonder then, that science is boring and disinteresting to some if not most learners, especially rural school learners.

Secondly, I have generated descriptive tables that included means and standard deviations for each measure. The purpose of this exercise is to summarise and to describe data so as to provide a general impression of the extent of the scientific experiences and engagement with public scientific issues of grade 11 learners, and the extent to which scores dispersed around the central tendency or the general impression. The unit of analysis for the generation of statistics was each individual (*n = 225*).

Table 1 below, displays the means and standard deviations for the scientific experiences of Grade 11 learners. The item scale was 1 *(never)* to 4 *(more often)*; the midpoint of the scale was 2.5.

Table 1 - Descriptive statistics for the sample of 225 learners on the scientific experiences and engagement with public science

Item	Descriptor	*n*	*M*	*SD*
Item 1	Reading science articles in magazines and newspapers	225	1.49	0.768
Item 2	Watching science programmes on Television	225	1.75	0.940
Item 3	Reading books about the life histories of scientists	225	1.55	0.760
Item 4	Talking about science topics with friends	225	2.47	0.986
Item 5	Listening to science or medical reports on news	225	1.60	0.829
Item 6	Visiting a natural history or science centre	225	1.41	0.803
Item 7	Visiting a national park, nature preserve or wild life refuge	225	1.63	0.785
Item 8	Taking something apart to see how it works	225	2.18	0.893
Item 9	Fixing something mechanical or electrical	225	2.16	1.077
Item 10	Performing chemical experiment or using a chemistry set	224	1.80	0.976

Note. *1(never) 2(seldom) 3 (fairly often) 4 (more often)*

The mean score for each descriptor in items 1 and 6 were below 2. This indicated that the respondents generally have *never* had the out-of-school scientific experiences described in each of these items. The standard deviations for these items were *low* and ranged between 0.77 and 0.80. This shows a narrow dispersion of scores around the general tendency of *never* reading science articles in magazines and newspapers, and visiting a natural history or science centre or a nature centre.

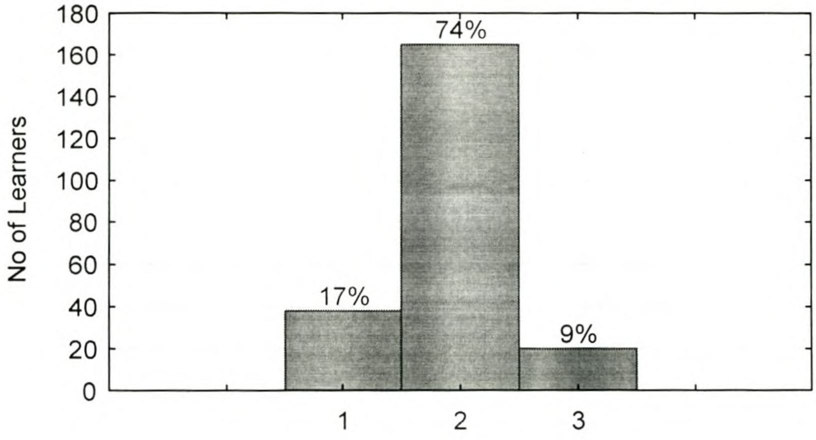
The mean score for items 2,3,4,5,7,8,9,and 10 were around 2. This indicated a general tendency of *seldom* engagement with the scientific experiences described in these items. The standard deviations for items 3,5,7 and 8 were *low* and ranged between 0.76 and 0.89.

However, the standard deviations for items 2,4,9 and 10 were a bit *high* and ranged between 0.94 and 1.07. It would be interesting to account for this rather wide dispersal of scores. Perhaps, gender differences in the scientific experiences of these learners played themselves out. It would be interesting to look at this in the subsequent analysis of variance.

4.2.2 *Level of interest and being well informed about scientific issues*

The description of the patterns of responses of Grade 11 learners in each of the seven items on the level of interest and being well informed about scientific issues are presented below. *Firstly*, responses to each of the items are analysed and documented using histograms to present the frequency of occurrence of each response category. *Secondly*, a table displaying the means and standard deviations for the level of interest and being well informed about scientific issues is presented to give the general and overall impression of the responses to each of the items.

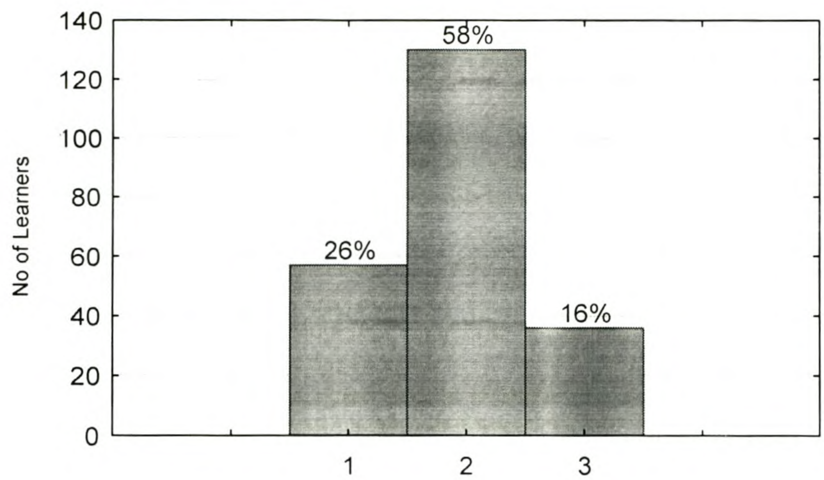
Figure 11: Level of interest in New developments in Science and Technology



Only *seventeen percent* of the Grade 11 learners expressed a *high level of interest and being well informed* about scientific issues. *Seventy four* percent report that they have *high level of interest but are not well informed* about new developments in Science and Technology. Only a small number of respondents, *nine percent* indicated that they were *neither interested nor informed*.

Figure 12 shows the distribution of responses for item 2 on the level of interest and being informed about scientific issues.

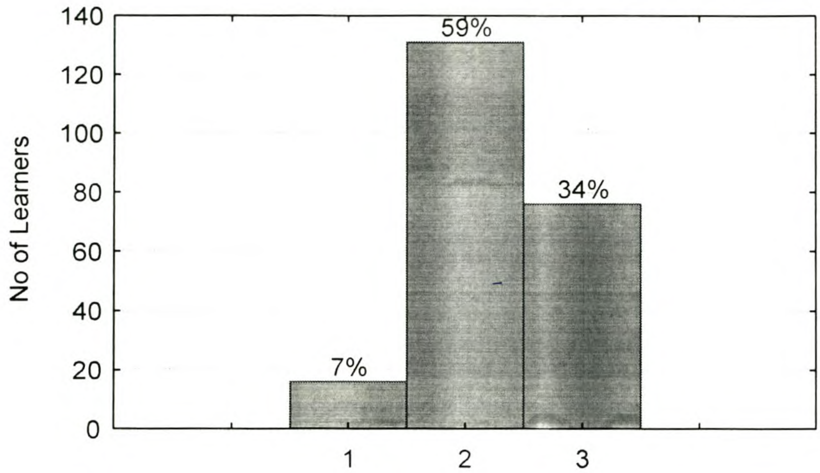
Figure 12: Interest on the use of new inventions and technologies



The level of interest in new inventions and technologies varied. *Twenty six* percent of the learners indicated *high level of interest and being well informed* about scientific issues. *Fifty eight* percent reported *high level of interest but not well informed* about this scientific issue. Only *sixteen* percent of the learners were *neither interested nor informed* about the use of new inventions and technologies.

Figure 13 shows the distribution of responses for item 3 in the questionnaire on the level of interest and being informed about scientific issues.

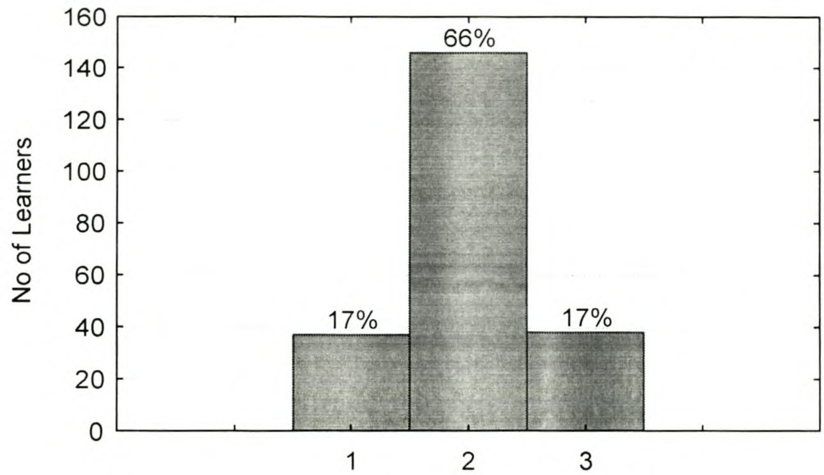
Figure 13: Level of interest in new medical discoveries



Only *seven* percent of the learners reported a *high level of interest and being well informed* about this scientific issue. *Fifty nine* percent indicated that they have *high level of interest but not well informed* about new medical discoveries whereas *thirty four* percent indicated that they are *neither interested nor informed.*

Figure 14 is the presentation of the distribution of responses for item 4 in the questionnaire on the levels of interest and being well informed about environmental pollution.

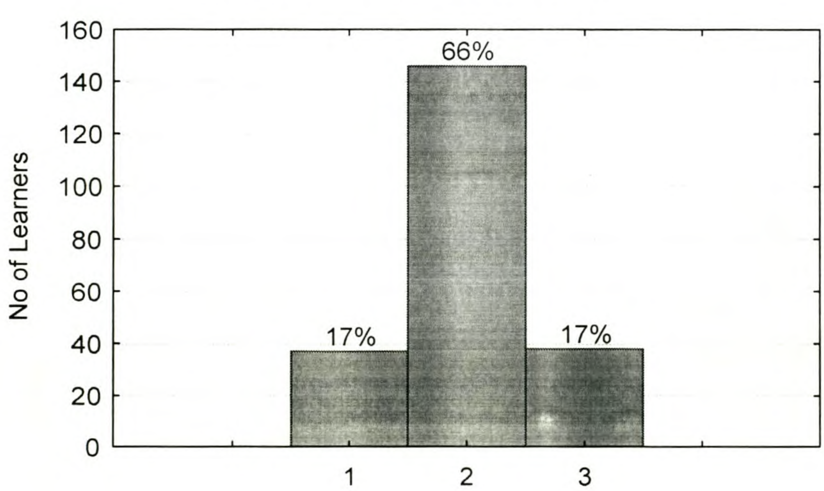
Figure 14: Level of interest in environmental pollution



Sixty six percent of the respondents reported a *high level of interest but had no knowledge or information* about environmental pollution. *Seventeen* percent reported being *interested and well informed* whereas another *seventeen* percent indicated that they were *neither interested nor informed*.

A histogram for the distribution of responses for item 5 is presented in figure 15.

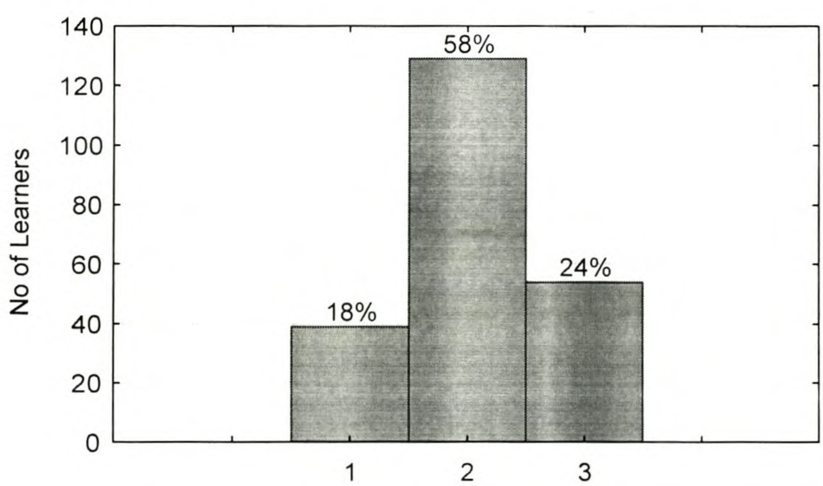
Figure 15: Level of interest in space exploration



The results for this item are similar to those of item 4 with *sixty six* percent of the learners indicating that they are *interested but not well informed* about space exploration. *Seventeen* percent reported *interest and being well informed* whereas another *seventeen percent* reported that they were *neither interested nor informed* about space exploration.

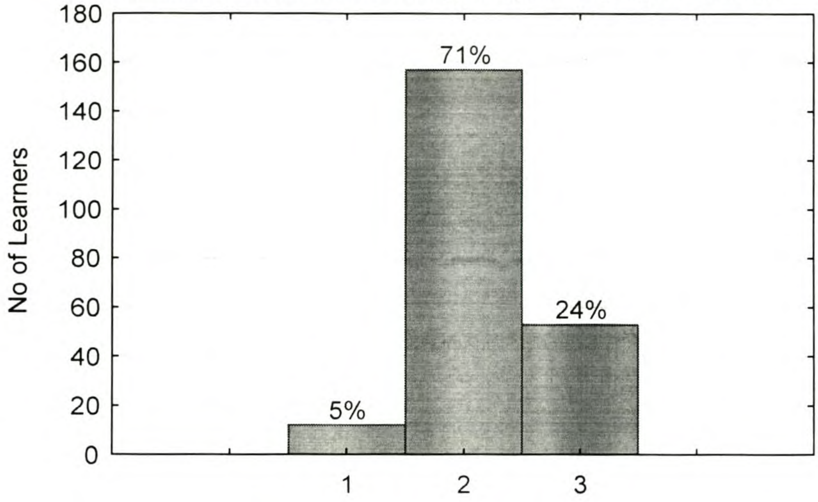
Figure 16 shows the distribution of responses for the level of interest and knowledge about information technologies and computers.

Figure 16: Level of interest in information technologies and computers



Eighteen percent reported that they are *interested and well informed* whereas *twenty four* percent indicated that they are *neither interested nor informed. Fifty eight* percent of the respondents indicated a *high level of interest but not well informed.*

Figure 17: Level of interest in biotechnology and genetically engineered foods



In figure 17 only *five* percent of the learners indicated a *high level of interest and being well informed* about biotechnology and issues around genetically engineered foods. *Seventy one* percent reported a *high level of interest but indicated that they were not well informed* whereas *twenty four* percent indicated that they were *neither interested nor informed* about scientific issues.

Items ranking high with high percentages indicating high level of interest but NOT being informed about scientific issues were the following:

- New developments in Science and Technology (74%)
- Biotechnology and genetically engineered foods (71%)
- Environmental Pollution (66%)
- Space Exploration (66%)

Items that ranked high with high percentages indicating neither interest nor information were the following:

- New medical discoveries (34%)
- Information Technologies and Computers (24%)
- Biotechnology and genetical engineering (24%)

These areas have triggered a lot of controversy, debate by members of the public, both informed and uninformed. Yet a sizeable number of learners from the sample indicated that they were neither interested nor informed about such socio-scientific issues.

These findings indicate that classroom science teaching and learning rarely links up with public and contemporary science or socio-scientific issues (Osborne, 2000). The fact that learners are interested in these issues cannot and should not be ignored. It attests to the need for a school science curriculum that has as one of its goals the public understanding of science.

Table 2 below displays the means and standard deviations for the level of interest and information about scientific issues of Grade 11 learners. The item scale was *1(highly interested and well informed*); *2* (*high interest but not informed) and 3 (neither interested nor informed).*

Table 2.- Descriptive statistics on the level of interest and information about about scientific issues

Item	Descriptor	*n*	*M*	*SD*
Item 1 -	New developments in Science and Technology	223	1.92	0.54
Item 2 -	New inventions and technologies	223	1.91	0.64
Item 3 -	New medical discoveries	223	2.27	0.58
Item 4 -	Environmental pollution	221	2.00	0.58
Item 5 -	Space exploration	222	2.07	0.65
Item 6 -	Information technologies and computers	221	1.93	0.56
Item 7 -	Biotechnology and genetically engineered foods	222	2.18	0.51

Note. Scale range = 1(interested and well informed) to 3 (neither interested nor informed).

The mean scores for all the descriptors on the level of interest and information about scientific issues were around 2. This indicated that the respondents generally have a *high level of interest but NOT well informed* about the scientific issues described in these items. The standard deviations for these items were *low* and ranged between 0.51 and 0.65. This shows a narrow dispersion of scores around the general tendency of having high levels of interest but NOT being well informed.

Therefore, a conclusion can be drawn with 95% confidence that Grade 11 learners are interested but NOT informed about scientific issues around new developments in Science and Technology, use of new inventions and technologies, medical discoveries, environmental pollution, space exploration, information technology, biotechnology and genetic engineering.

These findings show that the science curriculum, including its teaching and learning is not integrated with public and social scientific issues nor is it enabling learners to be engaged with debates, issues and developments in the fields of science.

The findings also confirm my observation and hunch of this research that the science curriculum focuses mostly on principles, formulae, laws and pays limited attention to the pupils' everyday lives or the socio-scientific issues (Osborne & Collins, 2000).

4.3 RESULTS OF THE ANALYSIS OF SIGNIFICANT DIFFERENCES

The literature reviewed has exposed not only gender bias in science teaching and learning but also, differences in the extracurricular experiences of the learners, with males having more extracurricular experiences compared to females. The hands on experiences of male and female learners also account for the fact that they favour different curriculum components. It is against this background that significant differences between male and female out-of-school scientific experiences, levels of interest and being informed about scientific issues are analysed.

4.3.1 *Significant differences between the out of school scientific experiences of male and female Grade 11 learners*

ANOVA was used to test significant differences between the scientific experiences of Grade 11 learners. This test statistic determines that differences exist among the means. A matrix is yielded where asterisks indicate significantly different group means. An alpha level of significance was set to 0.05. A calculated p – value of less than 0.05 indicates a significant difference.

Table 3 below shows the calculated p – values for the scientific experiences items. Gender was used as a primary sorting variable with 1 denoting females and 2 denoting males.

Table 3.- Significant differences between the scientific experiences of male and female Grade 11 learners

Item	Variable / Measure	*Significance p - value*
Item 1 -	Reading science articles in magazines and newspapers	0.001*
Item 2 -	Watching science programmes on television	0.006*
Item 3 -	Reading books about the life histories of prominent scientists	0.027*
Item 4 -	Talking about science topics with friends	0.030*
Item 5 -	Listening to science or medical reports on news programmes	0.63
Item 6 -	Visiting natural historyor science centre or a nature centre	0.005*
Item 7 -	Visiting anational park, nature preserve or wildlife refuge	0.62
Item 8 -	Taking something apart to see how it works	0.000*
Item 9 -	Fixing something mechanical or electrical	0.000*
Item 10 -	Performing a chemical experiment or using a chemistry set	0.000*

Note. Marked differences are significant at p<0.05

As can be seen in table 3, the marked scientific experience items were characterized by significant differences between the mean scores of male and female Grade 11 learners.

The scientific experiences for which there were significant differences were the following:

- Reading science articles in magazines and newspapers
- Watching science programmes on television
- Reading books about the life histories of prominent scientists
- Talking about science topics with friends
- Visiting a natural history or science centre or a nature centre
- Taking something apart to see how it works

- Fixing something mechanical or electrical
- Performing a chemical experiment or using a chemistry set

For the unmarked scientific experience items, there were no significant differences between male and female Grade 11 learners. The unmarked scientific experience items were the following:

- Listening to science or medical reports on news programmes.
- Visiting a national park, nature preserve, or wildlife refuge.

These results of the significant differences for the scientific experiences described are explained by literature. The differences in the extracurricular experiences of the learners with males having more extracurricular experiences compared to females accounts for these differences. The hands on experiences of males and female learners also differ and this fact accounts for the differences in items 8, 9 and 10 (Meador, 1999; Jones et al, 2000; Hu et al, 2003). These significant differences are pointers to the different perspectives, motivational traits, roles and situations shared by male and female Grade 11 learners. Science curriculum, including its teaching and learning rarely accommodate these differences.

4.3.2 *Significant differences in the level of interest and being informed about scientific issues*

Table 4.- Analysis of differences on the level of interest and being informed about scientific issues between male and female grade 11 learners

Item	Variable / Measure	*Significance p -value*
Item 1 -	New developments in Science and Technology	0.113
Item 2 -	Use of new inventions and technologies	0.028*
Item 3 -	New medical discoveries	0.000*
Item 4 -	Environmental pollution	0.425
Item 5 -	Space exploration	0.441
Item 6 -	Information technology and computers	0.422
Item 7 -	Biotechnology and genetically engineered foods	0.000*

Note. *Marked differences are significant at $p<0.05$*

As can be seen in table 4, the marked items (2,3 and 7) indicate significant differences between the mean scores of male and female Grade 11 learners. The level of interest and being informed about scientific issues items for which there were significant differences were the following:

- Use of new inventions and technologies
- New medical discoveries
- Biotechnology and genetically engineered foods

For the unmarked level of interest and being informed about scientific issues items (1,4,5,and 6), there were no significant differences between male and female Grade 11 learners. The unmarked level of interest and information items were the following:

- New developments in Science and Technology
- Environmental pollution
- Space exploration
- Information technologies and computers

4.4 SUMMARY OF THE FINDINGS

There are severally significant findings from this data.

Firstly, the respondents generally indicated that they have *never* had the following scientific experiences: reading science articles in magazines and newspapers; visiting a natural history or science centre or a nature centre. On the other hand, respondents expressed that they *seldom* engage themselves with public scientific issues by watching science programmes on television; read about life histories of scientists; talk about science topics with friends and listen to science reports on news programmes.

Generally, respondents *seldom* engaged themselves with practical science outside the classroom in the form of taking something apart to see how it works, fixing something mechanical or electrical and performing a chemical experiment or using a chemistry set.

Generally, Grade 11 learners expressed high levels of interest and feelings of NOT being informed about scientific issues.

Secondly, there were significant differences between male and female Grade 11 learners with respect to the following experiences: reading science articles, watching science programmes, reading about life histories of scientists, talking about science topics, visiting science centres, taking something apart, fixing something mechanical or electrical and using a chemistry set.

There were also significant differences between male and female Grade 11 learners with respect to the following interest and information topics and issues: use of new inventions and technologies, medical discoveries, biotechnology and genetically engineered foods.

Chapter 5 is set aside for a more detailed discussion of the significance of the findings for curriculum planners and developers, science teaching and learning and further research.

CHAPTER 5

IMPLICATIONS OF THE FINDINGS

5.1 INTRODUCTION

In this chapter, larger relevance, significance and value of the study is shown with regard to the possible implications for science curriculum planning, design and development, science teaching and learning and for further research.

5.2 IMPLICATIONS

5.2.1 Implications for science curriculum planning, design and development

Firstly, having information about the outside the school scientific experiences, level of interest and being informed about socio-scientific issues, debates and developments not only indicate learners' involvement with public and everyday science but also show niches for intervention. For example, learners expressed interest in scientific issues and developments but indicated that they were not well informed about such issues and developments. Leaving public understanding and engagement of learners with science to teachers' goodwill can only mean that learners will be exposed to public and everyday science sporadically, unevenly, or not at all. Activities that foster public engagement with science should be part of the science curriculum.

Secondly, significant differences in the outside the school scientific experience, levels of interest and being informed about socio-scientific issues are pointers to the need for a science curriculum that is free of gender bias. The science curriculum should be tailored around and address the needs of diverse audiences with different motivational traits, preferences for particular types of learning activities and modalities. It is through consideration of this fact that public understanding of science and 'science for all' can be achieved.

Thirdly, the study of some issues raised by contemporary science in any science course post-14 should be an integral part of the curriculum. These would include amongst others: ethical issues in science and history of science.

5.2.2 Implications for science teaching and learning

With regard to gender differences in the outside the school scientific experiences and socio-scientific issues, the teaching community must recognise and be sensitive to the need to create an academically and emotionally supporting environment for all learners (Meador, 1999:10). Teachers should endeavour to provide compensatory hands-on experiences in the science classroom, especially to females and afford them the opportunity to experience science through visits to science centres and interactions with scientists.

Gender bias in science teaching and learning should be addressed. Teachers should be encouraged to challenge and change students' ideas about gender-appropriate careers in Science and Technology. Teachers need to enrich their science lessons by including more contemporary examples so that school science appeared, to address the same issues as science in the media. The inclusion of elements which can add 'fun' to school science and opportunities for discussion can enhance the variety of experience and appeal, thereby kindling curiosity, surprise and interest.

5.2.3 Implications for further research

The results of this research represent a small piece of potential research on the scientific experiences of learners outside the school. The study can be extended to include learners from urban schools, so as to ascertain significant differences between rural and urban school learners.

More research is needed to identify current practices, which inhibit females' performance, and new practices that could overcome their lack of interest and confidence in Science and Technology (Meador, 1999:11).

5.3 CONCLUSION

The results of this investigation have shown that generally the Grade 11 learners have never had the outside the classroom scientific experiences described in the questionnaire. Results also show that these learners seldom engage themselves with the scientific activities, issues and developments beyond classroom science. Learners expressed high levels of interest in scientific issues and developments but indicated that they were not informed about such issues and developments. These results indicate virtual absence of socio-scientific issues in the science curriculum. Clearly, there is no connection between school science and everyday scientific activities of the learners and public science.

These results are challenging science curriculum specialists and science educators to make science education interesting and appealing to all learners irrespective of gender, and also to make science in the classroom relevant by connecting it to public science.

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Appendices

Appendix 1: Questionnaire on the out of school scientific experiences and public understanding of science

Questionnaire on the out of school scientific experiences and Public Understanding of Science

Section 1
General Information

Circle the appropriate number

Gender

1 Female

2 Male

Age

1 <17

2 17

3 18

4 19

5 20+

Location of the school

1 rural area

2 urban area

Which of the following subjects are you enrolled?

Circle all applicable numbers

1 Mathematics

2 Physical Science

3 Biology

4 Technology Subject

Section 2
Scientific Experiences

On a scale of 1 to 4, circle one number for each description to show the extent of your scientific experiences and engagement with public scientific issues.

1 Never
2 Seldom
3 Fairly often
4 More often

1. I read science articles in magazines and newspapers. 1 2 3 4

2. I watch science programmes on television (For example: Nature, Discover and National Geographic). 1 2 3 4

3. I read books about the life histories of prominent scientists. 1 2 3 4

4. I talk about science topics with my friends. 1 2 3 4

5. I listen to science or medical reports on news programmes. 1 2 3 4

6. I have visited a natural history or science centre or a nature centre. 1 2 3 4

7. I have visited a national park, nature preserve, or wildlife refuge. 1 2 3 4

8. I have taken something apart to see how it works. 1 2 3 4

9. I have fixed something mechanical or electrical (For example: a bicycle or a heater). 1 2 3 4

10. I have performed a chemical experiment or used a chemistry set. 1 2 3 4

Section 3
Level of interest and being well informed about scientific issues

On a scale of 1 to 3 indicate your level of interest and feelings of being informed about scientific issues.

1 High level of interest and well informed

2 High level of interest but NOT well informed

3 Neither interested nor informed

1. New developments in Science and Technology. 1 2 3
2. Use of new Inventions and Technologies. 1 2 3
3. New medical discoveries. 1 2 3
4. Environmental Pollution. 1 2 3
5. Space Exploration. 1 2 3
6. Information Technology and Computers. 1 2 3
7. Biotechnology and genetically engineered foods. 1 2 3

Thank you for completing this questionnaire

VAK: ....

TITELNR.: 586515 ....

DATUM: ....

SKENKER/HERKOMS: ....

....

BESIT: ....

DUPLIKAATOPNAME: ....

HANDTEKENING: ....

BESTEMMING: ....