

UNIVERSITY OF CAPE TOWN
FACULTY OF EDUCATION

**IMPROVING THE TEACHING AND LEARNING OF
SCIENCE AND TECHNOLOGY IN SOUTH AFRICA:
CONGRUENCE BETWEEN NORTH WEST SCIENCE
TEACHERS AND SCIENCE EXPO STUDENTS**

A dissertation presented to the University of Cape Town in partial fulfillment of
the requirements for the degree of MASTER OF EDUCATION

by

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July 1998

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DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Education in the Faculty of Education of the University of Cape Town. It has not been submitted before for any degree or examination in any other university.

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Zoleka N. Sokopo

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ABSTRACT

The purpose of this empirical investigation is to determine how closely the science and technology curriculum views of South African science teachers concur with those of science Expo students in 1997. The study is also a substantial contribution to an on-going national survey of the views of more than 1000 respondents for improving the teaching and learning of school science and technology as part of the Reconstruction and Development Programme.

The 1995 Government White Paper states that there is a need for curriculum development that includes finding criteria to prepare and recruit students for subjects in short supply, particularly science, mathematics and technology. In its statement of *Values and Principles of Education and Training*, the White Paper (15 March 1995:22) states: -

An appropriate mathematics, science and technology education initiative is essential to stem the waste of talent, and make up the chronic national deficit in these fields of learning, which are crucial to human understanding and to economic advancement.

Subsequent to the release of the White paper, a panel of seven South African researchers reviewed the science and technology (S&T) literature and extracted fifteen possible policy recommendations for the improvement of teaching methods, curriculum and textbooks in science and technology programmes.

The literature-derived 17-item survey instrument has been trialled, refined and used to conduct surveys of a variety of samples – science lecturers, Tsonga college science students, English/Afrikaans/Xhosa science students, science Expo students and Xhosa science teachers. The test/re-test reliabilities of the instrument, ranging from $r = 0.88$ to $r = 0.97$, were obtained using samples of $N = 47$ and $N = 14$ respondents over periods varying from seven days to seven weeks.

The respondents surveyed in this study in 1997 formed three samples. These comprised 134 rural high school Setswana-speaking science teachers from the North West Province;

200 science Expo students who entered the 1997 South African national science Expo for young scientists and 75 Cape Town science Expo students who were entrants in the regional science Expo competition.

Data was collected from the Setswana-speaking science teachers using the normal school-education office postal system of the North West Department of Education. Data collection from both samples of Expo students was carried out during the judging on the first day of the local or national competition. The data was analysed using chi-square (χ^2) tests for 2 x 2 contingency tables contained in a Statgraphics computer package for the purpose of disclosing significant differences in agreement or disagreement between the three samples for each of the 15 items presented to them. In addition, chi-square tests were used to disclose significant differences between the three samples in their choice of best or least important policy recommendations from the 15 proposed items. For tables with frequencies less than five, Fisher exact probability test was used. Ordinal ranking of the frequencies to the responses of the 17-item survey-instrument was used to determine the best and least priority recommendations.

All three samples chose item 1 *'introducing more real life skills in science'* as the best policy recommendation for improving science and technology teaching. Item 8 *'using more self-discovery and self-teaching in science'* was chosen as the second priority by 134 Setswana-speaking science teachers and 200 Pretoria science Expo students. However, the 75 Cape Town science Expo students chose item 12 *'using computer-aided instruction in science'* as their second priority and item 8 as their third recommendation.

All three samples rejected item 2 *'introducing more gender issues in science'* and item 5 *'introducing more attention to language in science'* as a means of improving the teaching and learning of science and technology. Item 15 *'using African indigenous science'* also tended to be rejected as an important or major policy recommendation by all three samples.

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LIST OF ABBREVIATIONS

ACER	-	Australian Council for Educational Research
ANC	-	African National Congress
AS&TS	-	Associated Scientific and Technical Societies
DACST	-	Department of Arts, Culture, Science and Technology
ed	-	editor
eds	-	editors
ESI	-	Exposcience Internationale
et al.	-	and others
FRD	-	Foundation for Research and Development
HSRC	-	Human Sciences Research Council
IDRC	-	International Development Research Centre
JCSS	-	Joint Council of Scientific Societies
LOTE	-	Languages Other Than English
MILSET	-	Mouvement International pour le Scientific et Technique
NECC	-	National Education Co-ordinating Committee
NEPI	-	National Education Policy Investigation
OBE	-	Outcomes Based Education
PASET	-	Public Awareness of Science and Technology
RDP	-	Reconstruction and Development Programme
RSA	-	Republic of South Africa
S&T	-	Science and Technology
SAATPS	-	South African Association of Teachers of Physical Science
SAIRR	-	South African Institute of Race Relations
SAQA	-	South African Qualifications Authority
SAVI	-	South African Engineering Association
SCISA	-	Science Curriculum Initiative in South Africa
SET	-	Science, Engineering and Technology
S-E-T	-	Science-Engineering-Technology
STS	-	Science-technology-society

TIMSS	-	Third International Mathematics and Science Survey
UNEP	-	United Nations Environmental Programme
UNESCO	-	United Nations Education, Scientific and Cultural Organisation
USICEE	-	UNESCO Supported International Centre for Engineering
YEAST	-	Year of Science and Technology

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CHAPTER 1

INTRODUCTION

1.1 Statement of the problem

In 1996 the Human Sciences Research Council of the Republic of South Africa emphasised that scientific investigations would contribute towards the realisation of the goals of the Reconstruction and Development Programme of the new government (Ndebele, 1996:10). This HSRC initiative flowed from the *White Paper on Education and Training in a Democratic South Africa* (RSA, 1995) which was released by the Government of National Unity.

In its statement of *Values and Principles of Education and Training Policy* (RSA, 1995: 21), the White Paper states that an appropriate mathematics, science and technology initiative is essential to make up the chronic national deficit for economic advancement.

The White Paper (RSA, 1995:18) further states that, due to gross inequalities in education, South Africa is struggling with needs for social justice, employment creation, housing, primary health care, environmental protection, and educational services. This has resulted in the majority of the population having low levels of life expectancy, basic health and nutrition, real life skills and productivity.

The findings reported in this dissertation, prompted by the release of the White Paper in 1995, have been published recently in the *Global Journal of Engineering Education*, 1997, vol. 1, no. 2, pp. 103-118. The article is entitled, "Improving the teaching of science and technology in the new South Africa: Concurrence between the policy preferences of lecturers, teachers and students". A copy of this full article is attached in Appendix 1.

CHAPTER 1

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In its statement of *Values and Principles of Education and Training Policy*, the White Paper (RSA, 1995:22) advocates: -

- “17. The curriculum, teaching methods and textbooks at all levels and in all programmes of education and training should encourage *independent and critical thought*, the capacity to question, enquire, reason, weigh evidence and form judgements, achieve understanding, recognise the provisional and incomplete nature of most human knowledge, and communicate clearly.
18. *Curriculum choice, especially in the post-compulsory period*, must be diversified in order to prepare increasing numbers of young people and adults with the education and skills required by the economy and for further learning and career development.
19. *An appropriate mathematics, science and technology education initiative* is essential to stem the waste of talent, and make up the chronic national deficit, in these fields of learning, which are crucial to human understanding and to economic advancement.
20. *Environmental education*, involving an interdisciplinary, integrated and active approach to learning, must be a vital element of all levels and programmes of the education and training system, in order to create *environmentally literate and active citizens* and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources.”

In 1997, a more updated government scientific policy on education has emphasised that science must be accessible to all South Africans in view of its potential to improve the quality of life (Department of Education, 1997:142). Looking ahead, South Africa through the Department of Arts, Culture, Science and Technology has officially declared 1998 as the “*Year of Science and Technology*”. This was done in recognition of the importance of science, engineering and technology (SET) in the establishment of a national system of innovation that is essential in improving our country’s economy (FRD News, August 1997: 2).

It is against this background, and in this context that the policy findings on the most important suggestions, agreed upon by consensus, for improving the teaching and learning of the current science and technology curricula are reported in this dissertation.

1.2 Purpose of the study

The objectives of this investigation were: -

- (1) to develop an efficient data gathering instrument to assess the curriculum priorities of science students and teachers in order to try to improve the teaching of science and technology in South African schools, and then to compare these responses with those of other interested groups, and
- (2) to determine which of fifteen possible policy recommendations for the improvement of current programmes of science-engineering-technology (S-E-T) would be most highly prioritised and agreed upon in 1997 by a sample of 134 Setswana-speaking science teachers in the North West Province, and by two samples of South African aspirant young scientists (275 science Expo students) from senior high schools across South Africa.

1.3 Origin and background to the study

The White Paper states that there is a need for curriculum development (RSA, 1995: 27) that includes finding criteria to prepare and recruit students for subjects in short supply, particularly science, mathematics and technology (p.30).

A recent study of practical work in science teaching in developing communities has pointed out that these communities fail to produce sufficient numbers of graduates in technology and in science-related professions, suggesting that this is caused by the dominance of lecturing as a teaching method, and by the lack of a practical approach in science teaching (van de Linde *et al.*, 1994:48). why

Other reasons previously cited for African students' reduced interest in science were the dull and uninteresting way in which the subject was presented; but the underachievement of science students in Nigeria, including the dropping of science after matriculation, was attributed not to a single cause, but to a combination of factors which were thought to be somehow associated (Kahn, 1988:349).

A study in South Africa at about the same time revealed that final year high school pupils considered science a difficult subject, but the main problems were considered to be a lack of suitably qualified teachers who then blamed the lack of apparatus and facilities (Wilkinson, *et. al.* 1987:47). Gray (1997:100) found that even after a period of ten years these circumstances had remained unchanged.

In Australia it has been reported recently that Aboriginal and Torres Strait Islander students also recorded low enrolments in the physical sciences and mathematics; and that, nationally, males have been predominant in the physical sciences and technical studies, while females have appeared in proportionately greater numbers in languages other than English (LOTE), home economics and biological and other sciences (ACER, 1995:1).

Furthermore, in the United States of America, not all students with an interest in, and an aptitude for, tertiary level studies in engineering, science and technology continue their inclination towards this area of academic concentration. In the United States of America, for example, poor science teaching, lack of nurturing, science being considered too difficult and time consuming, and particularly negative experiences in science courses have been cited as important reasons for a 40% nation-wide attrition rate among science majors (Brand, 1995:180).

In South Africa, similar reasons have been suggested by students for avoiding or under-achieving in science or technological subjects (Rochford and Mandla, 1997:326).

1.4 Importance of the research problem

The study is deemed to be particularly important because recently it has been determined that, whereas countries like Japan boast 71 scientists and engineers for every 1000 people, Canada 64, and United Kingdom 53, in South Africa the figure is only 3.3 and falling (South African Institute of Race Relations, 1997:157). The survey further states that a country like Brazil, a developing country similar to South Africa, has 11 scientists and engineers per 1000 people (p.157). South Africa is therefore faced with the problem

of having to increase drastically its science graduates over the next decade – particularly in the areas of engineering and agriculture in order to develop economically (South African Institute of Race Relations, 1997:158).

The new science curriculum (Department of Education, 1997:142) aims to develop appropriate skills, knowledge and attitudes and an understanding of principles and processes that will prepare school science pupils to: -

- contribute to the creation and shaping of work opportunities;
- enable learners to make sense of their natural world;
- conserve, manage, develop and utilise natural resources to ensure the survival of local and global environments; and
- contribute to the development of responsible, sensitive and scientifically literate citizens who can critically debate scientific issues and participate in an informed way in democratic decision-making processes.

Thus, the obvious target groups for testing the feasibility and relative importance of such policies would include regional and national convocations of aspirant young science enthusiasts such as the science Expo competition (Science Talent Quest) entrants, and their science teachers.

1.5 The purpose of the study

The aims of the research are: -

- To determine the areas of agreement of Setswana science teachers, Cape Town science Expo students and Pretoria science Expo students on 15 suggested policy recommendations for making future improvements to school science and technology.
- To explain any significant areas of disagreement that might occur among the response trends of the three samples.
- To establish whether there are any statistically significant differences among the samples with regard to their choices of “*most important*” policy recommendations.

- To establish whether there are any statistically significant differences among the samples with regard to their choices of “*least important*” policy recommendations.
- To discover and make additional recommendations for adapting the existing data gathering instrument to suit the needs of future science teachers and their students in a wider variety of South African contexts.

1.6 Hypotheses

The following null hypotheses will be tested: -

- H₀1a** There will be no significant differences between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 200 Pretoria science Expo students (sample 2) in their frequencies of agreement or disagreement with each of the 15 proposed science and technology policy recommendations.
- H₀1b** There will be no significant differences between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 200 Pretoria science Expo students (sample 2) in their frequencies of best choice or of their least important priority for each of the 15 proposed science and technology policy recommendations.
- H₀2a** There will be no significant differences between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 75 Cape Town science Expo students (sample 3) in their frequencies of agreement or disagreement with each of the 15 proposed science and technology policy recommendations.
- H₀2b** There will be no significant differences between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 75 Cape Town science Expo students (sample 3) in their frequencies of best choice or of

their least important priority for each of the 15 proposed science and technology policy recommendations.

H₀3a There will be no significant differences between the responses of the 200 Pretoria science Expo students (sample 2) and the 75 Cape Town science Expo students (sample 3) in their frequencies of agreement or disagreement with each of the 15 proposed science and technology policy recommendations.

H₀3b There will be no significant differences between the responses of the 200 Pretoria science Expo students (sample 2) and the 75 Cape Town science Expo students (sample 3) in their frequencies of best choice or their least important priority for each of the 15 proposed science and technology policy recommendations.

1.7 Clarification of terms

1. **Science** means the subject physical science/ biology/ general science taught in South African schools.
2. **Science Expo** is an annual Science Talent Search competition for aspirant young scientists, mathematicians, technologists and inventors, held at regional and national levels in South Africa.
3. **Setswana** is one of South Africa's eleven official languages. It is mainly spoken by people residing in the North West Province. In this study 'Setswana' refers to people who live in the North West Province.

1.8 Limitations of the study

The study is limited to a cluster sampling of purposive groups of North West science teachers (Sample 1), Pretoria science Expo students (Sample 2) and Cape Town science Expo students (Sample 3) in 1997.

1.9 Assumptions of the study

The study assumes that all the volunteer science respondents are in an informed position to make decisions on: -

- the suitability of the fifteen suggested policy recommendations presented in a choice of home languages (English, Afrikaans, Xhosa, Tsonga);
- the choice of two best and two least important policy recommendations; and
- suggesting more policy recommendations to be included in the new science and technology curriculum.

1.10 Research approach

The survey research method has been used to collect the data. A literature-derived and refined 17-item data-gathering instrument was employed. Data from the 134 North West science teachers was collected by mail, and data from the Cape Town science Expo students and Pretoria science Expo students was collected promptly and efficiently face-to-face by means of group-administered questionnaires. Chi-square tests have been used to analyse and compare the response patterns in the data.

1.11 Organisation of the remainder of the dissertation

The next five chapters are arranged as follows: -

Chapter 2 elaborates on the theoretical background of the problem.

Chapter 3 describes the research methodology in detail.

Chapter 4 consists of the presentation of the quantitative results and a summary of the qualitative results.

Chapter 5 discusses the empirical research findings and the qualitative results; and the implications they might have for improving the science and technology curriculum, teaching and learning.

Chapter 6 formulates recommendations for further research, and presents the conclusions to the investigation.

1.12 Chapter summary

In this introductory chapter, the research problem has been formulated, and its background and significance stated. The aims of the research and the hypotheses, and key terms have been clarified, the assumptions of the study and the research approach used stated, and the limitations of the research mentioned.

The next chapter presents the theoretical framework of this study in more detail.

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CHAPTER 2

LITERATURE REVIEW

This chapter is divided into Part A - Context and Part B – The literature derived instrument.

PART A: THE THEORETICAL CONTEXT OF THE STUDY

In section 2.1, a brief overview is presented of the current status of school science and technology education in South Africa. Section 2.2 reviews the aims and objectives of the envisaged 'curriculum 2005' for science and technology. Finally, in Section 2.3, a review is made of the recent trends in science and technology education in different countries.

2.1. The current status of school science and technology education in South Africa

2.1.1 The national status of science education in South Africa

Gray (1997:322) reported the results of his survey conducted through the Human Sciences Research Council (HSRC) as part of the Third International Mathematics and Science Study (TIMSS). The report stated the results of a survey of 15000 pupils (grades 7 and 8) from more than 400 primary and junior secondary schools in South Africa. The TIMSS tests were designed to measure school mathematics and science achievements in order to help inform governments, policy makers and educators about the national levels of mathematics and science proficiency at key points in the education process.

According to the Gray (1997), the TIMSS study identified the following problems which contributed to the relatively poor performance in school mathematics and science in South Africa: -

1. Curriculum content was not linked to relevant, real life applications of science and mathematics theory (page 320).
2. The amount of school practical work was inadequate (page 320).
3. The amount of school time allocated to these subject focuses was inadequate. Gray found that student achievement in Mathematics and Science was directly related to the instructional time given to these subjects. South African school timetables allocated only 1½ - 2 hours per week for science, compared to 4-6 hours per week in the higher achieving countries (pages 95 & 334).
4. The general school and home environment was not conducive to effective learning. A relatively high proportion of homes were without electricity and other domestic services (page 314).
5. The size of mathematics and science classes was too large. For example, close to eighty students were present in one class, although the limit is forty-five (page 95). Hacker and Rowe (1998:49) found that class size influences dramatically the quality of teaching provided, with inferior informational teaching styles being adopted where the class size is large.

Gray (1997:322) summed up these findings by saying,

“From the results, there is ample evidence that South African students are lacking in the ability to grasp even basic concepts and problem solving skills in Mathematics and Science.”

In his research Gray also noted that a great number of schools had inadequate buildings, poor or non-existent libraries, laboratories and other facilities, overcrowded classrooms, textbook shortages, lack of teacher support mechanisms and weak school leadership. Also, many students come from a poor socio-economic background, and a big generation of pupils presently at school often have parents who themselves have, at best, a basic primary education, and therefore cannot assist with schoolwork (p.232).

Commenting on the results of the TIMSS tests, the HSRC concluded by saying: -

"If South Africa is to succeed in a rapidly changing competitive world where science, engineering and technology are becoming increasingly important, then a

premium must be placed on science and technology education", (The Cape Times: 14 August 1997).

Gray (1997:261) also reported that there was no significant difference in achievement between those students who occasionally speak the language of instruction at home and those who never speak this language at home. He concluded by saying the level of language proficiency by the teachers, the availability of books and time spent on task could be other contributing factors to poor achievement (p.262).

The survey by the Education Foundation (1997:1) found that access to, and enrolment in, mathematics and science was often inadequate. Whilst these subjects were compulsory in the junior secondary phase (i.e. up to grade 9), a large number of these pupils did not have access to these subjects. In their analysis of seven provinces (excluding the Eastern and Western Cape) they found that in 1995, 174 schools did not offer general science to their standard 6 pupils and 168 schools did not offer general science to their standard 7 pupils, affecting about 68 000 pupils. At standard 10 level 651 schools did not offer science. There was also an extremely high dropout rate in these subjects. For example, of every 100 pupils enrolled in mathematics in standard 8 (grade 10) in 1995, only 54 were enrolled in this subject in standard 10 (grade 12) in the same year.

The Education Foundations (1997:2) also found that most mathematics and science teachers are not qualified to teach these subjects. While 84% of science teachers are professionally qualified, only 42% are qualified in science. They stated that the quality of mathematics and physical science teacher education at colleges of education varied considerable. In the main, the quality of teaching was very poor and heavily reliant on teacher-centred approaches, with lecturers having little if any school experience and providing poor role models. The curricula, examinations or the methodology employed in these colleges showed little evidence of true innovation. In conclusion, the Education Foundation (p.3) stated that very few teachers from this system could be regarded as either mathematically or scientifically literate. Secondly, the division between theory and practice in the didactics courses generally did not prepare student teachers for the realities

they would face in the school system.

The Education Foundation emphasised that the current output of qualified science teachers is only 40% of the number needed (p.3). They suggested that the output of teachers in these subjects would have to double over the next three years in order to meet the country's needs. That is, about 3000 mathematics teachers and 3600 science teachers would be needed during the next three years.

2.1.2 The international status of science education in South Africa

According to the results presented by Gray (1997:162-234), South African students scored the lowest average in tests involving 15 000 schools around the world (that is, mathematics average = 356 and science literacy average = 349; and the average for both subjects in all 41 nations was about 500). Gray (p.332) alluded that the results indicated school students do not have adequate or the expected levels of problem solving skills as shown by the results they obtained in tasks that required these skills. He concluded by saying that South African teaching 'methods' focus too heavily on rote learning and insufficient attention is given to concept formation and problem solving (p.235).

Of the developing countries that participated in the TIMSS study (i.e. South Africa, Thailand, Iran and Columbia), only Thailand performed well in all four reporting fields (i.e. Upper and Lower Grade Mathematics and Upper and Lower Grade Science), (Gray 1997:171). Although this was the case, according to Gray (1997:330) South Africa did not match up to the performance of other developing nations that participated in the TIMSS.

For example, Table 2.1 on page 14 represents the overall international mean achievement scores for Science in the TIMSS for Standard 6 Upper Grade.

Table 2.1: TIMSS mean achievement scores in science for four developing countries

COUNTRY	ACHIEVEMENT MEAN SCORES IN SCIENCE
South Africa	326
Columbia	411
Iran	470
Thailand	525
International Average for Science Achievement – Upper Grade (Std 6) = 516	

Table adapted from Gray (1997:170)

Gray (1997:164) also found that the science curriculum content for South Africa generally does not match that of overseas curricula. He calculated the science curriculum fit percentage¹ for standard 5 to be 18% and for standard 6 to be 51%. In most countries that participated in the TIMSS the standard 5 curriculum fit lies in the range of 55-60% and the standard 6 in the range of 75-85%. According to Gray (p.332) this means that the content of the South African science curricula do not appear to be in step with the content of other international curricula. He highlighted topics like Human Biology and Earth Sciences which do not appear in the standard 5 or the standard 6 syllabi.

These findings led him to make the following comment: -

“ The current revisions taking place in South African curricula, it is hoped, will serve to bring local curricula more into line with those nations that participated in TIMSS whilst rightfully retaining their indigenous characteristics” (p.332).

¹ Gray (1997:163) describes "science curriculum fit percentage" as the degree of overlap between national/local curricula and the broad field of Mathematics and Science covered by the TIMSS question bank.

2.2 The new Science and Technology curriculum in South Africa

The release of the above reports by Gray coincided with a radical change in South Africa's schooling system. The South African Qualifications Authority (SAQA) has set essential outcomes that focus on the capacity to apply skills, knowledge and attitudes (Department of Education, 1997:1)

According to SAQA the following should be the outcomes of the years of schooling: pupils should be able to: -

1. Identify and solve problems and make decisions using critical and creative thinking;
2. Work effectively with others as member of a team, group, organisation and community;
3. Organise and manage themselves and their activities responsibly and effectively;
4. Collect, analyse, organise and critically evaluate information;
5. Communicate effectively using visual, symbolic and/or language skills in various modes;
6. Use science and technology effectively and critically showing responsibility towards the environments and health of others; and
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation (Department of Education, 1997:13).

SAQA (Department of Education, 1997:13) further stated that any programme of learning should make the individual aware of the importance of: -

1. Reflecting on and exploring a variety of strategies to learn more effectively;
2. Participating as a responsible citizen in the life of local, national and global communities;
3. Being culturally and aesthetically sensitive across a range of social contexts;
4. Exploring education and career opportunities; and

5. Developing entrepreneurial opportunities.

From the critical outcomes SAQA derived eight learning areas which include Natural Science (incorporating integrated sciences, biological sciences; physical sciences, agricultural sciences, engineering) and Technological Sciences (including technology education, information technology, technical education, applied arts and sciences).

The Natural Sciences

The following are specific outcomes (i.e. what the learners will be able to do) for the learning of Natural Sciences expected at the end of schooling from South African pupils:-

1. Use process skills to investigate phenomena related to the Natural Sciences.
2. Demonstrate an understanding of concepts and principles, and acquired knowledge in the Natural Sciences.
3. Apply scientific knowledge and skills to problems in innovative ways.
4. Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilisation of natural and other resources.
5. Use scientific knowledge and skills to support responsible decision-making.
6. Demonstrate knowledge and understanding of the relationship between science and culture.
7. Demonstrate an understanding of the changing and contested nature of knowledge in the Natural Sciences.
8. Demonstrate knowledge and understanding of ethical issues, bias and inequalities related to the Natural Sciences.
9. Demonstrate an understanding of the interaction between the Natural Sciences and socio-economic development (Department of Education, 1977:143).

Technological Sciences

For Technological Sciences the following are specific outcomes (i.e. what the learners will be able to do) expected at the end of schooling from South African pupils: -

1. Understand and apply the technological process to solve problems and satisfy needs and wants.
2. Apply a range of technological knowledge and skills ethically and responsibly.
3. Access, process and use data for technological purposes.
4. Select and evaluate products and systems.
5. Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems.
6. Demonstrate an understanding of the impact of technology.
7. Demonstrate an understanding of how technology might reflect different biases, and create responsible and ethical strategies to address them (Department of Education, 1997: 89).

2.3 Recent Trends in Science Education

The aims and goals of teaching science and technology in several other countries were also considered for constructing and selecting items to be included in the instrument used in this dissertation. If South Africa is to compete internationally, there is a need to look at the science education and technology education of other countries as well.

2.3.1 The United Kingdom

According to Watson and Prieto (1994:41) in England there was a strong emphasis on relating science to society as the skills and processes were placed in the context of practical work.

Recently the United Kingdom has emphasised teaching the social issues and responsibilities of science and technology. According to Watts *et al.* (1997:350), the current version of the National Curriculum requires that 16-year-olds should: -

1. Consider ways in which science is applied and used to evaluate the benefits and drawbacks of scientific and technological developments for individuals, communities and environments.
2. Use scientific knowledge and understanding to evaluate the effects of some applications of science on health and quality of life.
3. Relate scientific knowledge and understanding to the care of living things and the environment.
4. Consider competing priorities and the decisions that have to be made about energy requirements, taking into account relevant social, economic and environmental factors.
5. Consider the power and limitations of science, and addressing industrial, social and environmental issues and some of the ethical dilemmas involved.

2.3.2 Taiwan

Yager (1993:56) gave the following goals for science education in Taiwan: -

1. Learning basic scientific concepts.
2. Applying scientific knowledge to new real life situations.
3. Developing responsibility for environmental preservation.
4. Practising self-learning problem solving strategies.
5. Developing positive scientific attitudes.
6. Improving achievement in terms of creativity.
7. Preparing to be scientifically literate citizens.

2.3.3 The United States of America (USA)

The National Research Council (1996:13) of the United States of America formulated goals for schools science that underlie the National Science Education Standards. According to the National Research Council these goals define a scientifically literate society. The following goals describe what the USA students should understand and be able to do after 13 years of school science: -

1. Experience the richness and excitement of knowing about and understanding the

natural worlds.

2. Use appropriate scientific processes and principles in making personal decisions.
3. Engage intelligently in public discourse and debate about matters of scientific and technological concern.
4. Increase their economic productivity through the use of the knowledge, understanding and skills of the scientifically literate person in their careers.

2.3.4 The Netherlands

According to Jansen, Dijkstra and Bloem (1997a: 404) the general objectives of the new biology curriculum in Netherlands are to understand: -

1. The science of biology as subject, that is:
 - a) biological relations, for instance between structure and function;
 - b) interdependence within the biosphere, and the role of mankind; and
 - c) The way biological knowledge can be acquired; the meaning of biological data for the use of bacteria, fungi, plants, animals.
2. The impact of biology on the personal and social development of the students, that is:
 - a) consciousness about life, respect and responsibility for living beings for living and the biosphere;
 - b) application of biological knowledge in daily life (e.g. consumerism, health, sexuality, environment);
 - c) recognition of biological aspects in social settings, their positive and negative elements; formulating a considered personal perception for, among other things, decisions for personal behaviour; and
 - d) social skills, such as having regard for other people, seeing other points of view, communication.
3. The vocational education and professional future of the students, that is:
 - a) acquaintance with all aspects of biology as a field of study, important for choices for further education; and
 - b) acquaintance with biology as applied in vocational education and vocational settings.

2.3.5 Spain

According to Watson and Prieto (1994:40-41) the science curriculum in Spain puts more emphasis on: -

1. Developing scientific concepts.
2. Developing positive attitudes to science.
3. Learning scientific processes (processes such as developing hypotheses and designing experiments are often placed in a non-practical context).
4. Solving theoretical problems.

2.4 Implications for the development of some items in the instrument

The implications of this overview of the national and the international status of South African science education, the new science curriculum and recent trends for science education for this dissertation are that there is a continued substantiation for the inclusion of several items in the proposed survey instrument for the North West Province teachers and for Science Expo students. These are focusing especially on: -

1. Problem solving in science in the classroom.
2. Use of real life skills in science teaching.
3. Environmental issues to be included in science lessons.
4. Social and economic development issues related to science.
5. Attention to language in teaching and learning about science.
6. Science and technology careers to be mentioned in science lessons.
7. African indigenous technology and culture to be included in more science lessons.
8. Themes like citizenship, community development and health, ethical, cultural and decision making activities to be incorporated into science learning.
9. Issues of bias (e.g. gender, community, cultural, ethical) to be discussed in science lessons.
10. The use of technology in science lessons.
11. Creative learning to be fostered in science.

2.5 Conclusion

In Part A of this chapter the following were discussed: -

- The current status of school science and technology education in South Africa;
- The new Science and Technology curriculum in South Africa; and
- Several recent trends in science and technology education with special reference to the United Kingdom, the Pacific Regions, the United States of America, the Netherlands and Spain.

The above literature review gave a basis for the formulation, justification and clarification of the items for the survey instrument designed for use in this dissertation.

Part B follows, and it explains the related literature used for designing the research instrument more explicitly and comprehensively.

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PART B: THE LITERATURE-DERIVED INSTRUMENT

This section records how the wording of each of the 15 items comprising the survey instrument came from the literature review which focused on current policy recommendations for improving school science and technology education. Piloting, validation and reliability of the final instrument are discussed.

2.6 The development of the instrument and its statistical parameters

2.6.1 The 15 items and the theoretical basis for their selection

Item 1

"Introducing more real life skills in science and technology education (such as technical trade, industrial, commercial, agriculture, commercial, farming, mining, manufacturing, marketing and technological skills)."

One of the goals envisaged by the new 'Outcomes Based Education' (OBE) is that pupils should be able to demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation (Department of Education, 1997:13).

One of the ways to realise this policy proposal is to take into cognisance the recommendations by the South African Association of Teachers of Physical Science (1978:6) and Gray (1988:35), who suggested that science taught at school should be relevant to pupils' everyday experiences. Kyle, Naidoo and Yoloye (1996:343), Gray (1997:402), Lee (1997:114), Watts *et. al* (1997:350), and Wilkinson and Ward (1997:51) also support this recommendation.

The National Education Policy Investigation (NEPI) (1992:71) agreed with this recommendation and further stated that a greater depth of understanding of scientific concepts and their application in the everyday life of the learner stimulate the students'

interest and may encourage them to follow careers in science and technology.

Coles (1998:620) corroborates the argument that if school science was informed of the way science is practised in businesses and services, young people would be able to sample the activities which working scientists use. He emphasised that students should be able to make career decisions based on firmer, first-hand experience.

Item 2

"Paying more attention to gender issues in science and technology education (such as men and women in science, topics that cater for girls' interests and boys' interests, solutions to the existing gender problems in South Africa)."

The National Education Policy Investigation (1992:3) expressed the concern that for South Africa to be competitive in the modern industrialised world, an emerging pool of trained and motivated young men and women is necessary in the science, technology and engineering fields.

The ANC (1994b: 62 & 97) supported this notion by advocating that within all education and training programmes special attention must be given to women in the rural areas; campaigns and information should also open up a wider range of learning opportunities for women; and that girls and women should be encouraged to pursue non-traditional subjects such as mathematics and science. Solomon (1997:416) remarked that the choosing of science by females seems to be ring-fenced by culture.

Item 3

"Science and technology education should concentrate more on South African environmental issues (e.g. the problem of soil loss and possible solutions, health care, sanitation, air pollution, electricity supply, conservation of plant and animal species, etc)."

The White Paper (RSA, 1995:22) states that 'environmental education, involving an

interdisciplinary, integrated and active approach to learning, must be a vital element of all levels and programmes of the education and training system, in order to create environmentally literate and active citizens and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources.' This is further supported by Allsop (1991:60-61), Yager (1993:55), Science Curriculum Initiative in South Africa (1989:6), James *et al.* (1994:6), and Myburgh (1994:32).

SAQA (Department of Education, 1997:13) also emphasised that schooling should prepare pupils to be able to use science and technology effectively and show critical responsibility towards the environments and health of others.

Item 4

"Using science and technology to advance and develop the community socially and economically (e.g. to help solve social, labour, citizenship, social and ethical problems in South Africa)."

The Department of Education (1997) formulated specific outcomes for science and technology that are related to economic and community development. According to these envisaged outcomes, pupils should be able to demonstrate an understanding of the interaction between the natural sciences and socio-economic development (p.143), and they should be able to demonstrate an understanding of the impact of technology (p.89).

Connelly *et al.* (1985:139) emphasised that students should understand the role of science in the development of societies and the impact of societies upon science. Knamiller, (1984:63) observed that there is a persistent belief that science, more than any other subject in the traditional curriculum, is more closely associated with economic and social development. The Science Curriculum Initiative in South Africa (SCISA) (1989:6) also revealed that economic and political power in society increasingly has a technological base since those with technological knowledge and skills gain employment, status and material wealth. The document further explained that while the topics in the current syllabuses reflect the science used in technology, the applications of science to

technology are not at all explicit and there is no examination of how technology operates in the various sectors of our society. The ANC (1994:96) and the South African Association of Teachers of Physical Science (1978:9) also support this.

The results of a study by Solbes and Vilches (1997:385) on science-technology-society (STS) and the teaching of physics and chemistry supported that it is possible to transform physics and science material with the inclusion of STS activities in the development of each topic, in such a way that the students can build scientific knowledge, integrating essential aspects that affect scientific activities and contribute to deepening their knowledge. Students who took a course dealing with STS activities had a more contextualised and realistic idea of science than students who took courses that did not take these aspects into account. Secondly, students' attitudes and interest in the study of physics and chemistry was increased. Solbes and Vilches advised that the inclusion of STS in teaching will be important not only for the forming of citizens of a society that is more and more dependent on science and technology, but to promote students to adopt a responsible attitude toward scientific and technological development, and also form future scientists.

These arguments contributed to the inclusion of this item in the survey instrument.

Item 5

"Paying more attention to language in South Africa (such as teaching cultural meaning of scientific terms, teaching of science using mother-tongue, learning to understand terms and language, scientific English as a second language)."

Woolnough and Allsop (1985:79) maintained that the role of language is central to the development of appropriate ways for a student to personally make sense of the world. Curtis and Millar (1988:62) also claimed that language plays a crucial role in the child's ability to construct meaning. They have a conviction that the learning of abstract scientific concepts depends both on the child's ability to use language to explore his/her

existing conceptions and on the richness of the word and the idea-associations which the child has with particular scientific ideas involved.

Lee (1997:115) argues that students with limited literacy development in reading and writing often have not developed abstract and hypothetical reasoning. These students also experience difficulties appropriating scientific modes of discourse. Thus, they face the challenge of learning to talk in science as well as developing literacy simultaneously.

Kulemaka (1994) in Reinhard (1997:77) believed that one of the most important goals in education is that pupils utilise the knowledge they acquire in school in solving problems in their lives. He therefore suggested that, by teaching subjects in a language which pupils use in their home environment, we would be able to make an immediate connection between classroom knowledge and its application at home.

Baker and Taylor (1995:697) highlighted that several researchers suggested that the personal construction of meaning in science is related to the linguistic background of the learner, and to the compatibility of the learner's language with that of science education. Gray (1997:332) found evidence of language problems among the students, since 80% of the students that participated in the TIMSS study in South Africa wrote the test in a language that is not their first language. He therefore stressed that language might have a negative impact on achievement.

According to the South African Institute of Race Relations (1997:245) no language policy has been published but the government has appointed a task team to investigate the practicability of offering mother-tongue (first language) education in South Africa. These arguments were further corroborated by Henderson and Wellington (1998:35) who believe that for many pupils the greatest barrier to learning science is the language.

It is against this background that this item was included in the survey instrument.

Item 6

"Having the disadvantaged majority in South Africa as its focal point (that is, using education to empower communities to address their local problems resourcefully e.g. housing, sanitation, water, electricity, nutrition)."

The White Paper (RSA, 1995:21) advocates "basic education for all". In achieving this goal the White paper states that there must be special emphasis on the redress of educational inequalities among those sections of our society who have suffered particular disadvantages, or who are especially vulnerable, including street children, out-of-school youth, the disabled and citizens with special needs, illiterate women, rural communities, squatter communities, and communities damaged by violence.

The South African Association of Teachers of Physical Science (1978:6) suggested that the subject matter in science courses should be relevant to both the pupils' world and to the needs of South Africa. The document further suggested that our school science curriculum should include a component in which the relationship between science and society is dealt with.

The Department of Arts, Culture, Science and Technology (DACST) (1996:18) pointed out that the central and regional governments have a key role in ensuring that the social benefits resulting from SET development are widely distributed.

The item was included in the survey instrument on this basis.

Item 7

"Encouraging more competitions with more enterprises to be organised between schools and within schools in South Africa (such as students participating in Expo, science fairs, science Olympiad and science essay writing)."

The White Paper (RSA, 1995:22) suggested that an appropriate mathematics, science and technology education initiative is essential to stem the waste of talent, and to stem up the

chronic national deficit, in these fields of learning.

Woolnough (1997:71) suggested that in order to make our science teaching more effective, we need to concentrate on ways of developing the affective or giving students a sense of satisfaction and personal achievement in their science. He further suggested that the most cost-effective of all is the development of extra-curricular activities in science, with science clubs, science competitions, individual and group projects and stimulus activities, which do so much to fire the all important imagination of the students. According to Tytler and Swatton (1992:22) Science Fairs and Science Talent Search are platforms for students to show their investigative skills. Woolnough also maintained that,

“Unless students appreciate, enjoy and want to do science, it matters little what they know or can do. The best way of motivating them may not be through pure practical work.” p.67.

Hughes (1998:11) substantiates this by arguing that one excellent and long-standing vehicle for developing interest and skills in students as well as raising public awareness in science and technology, has been *Expo for Young Scientists*, which has been running in South Africa since 1980.

Item 8

"Making more use of self discovery and self-teaching (such as students designing more of their own experiments and field work; and developing skills of problem solving and creative thinking)."

The White paper (RSA, 1995:30) states that the curriculum, teaching methods and textbooks at all levels and in all programmes of education and training should encourage independent and critical thought, the capacity to question, enquire, reason, weigh evidence and form judgements, achieve understanding, recognise the provisional and incomplete nature of most human knowledge, and communicate clearly.

The Department of Education Curriculum 2005 (1997) advocated that pupils should be able to use process skills to investigate phenomena related to the natural sciences and be

able to apply scientific knowledge and skills to problems in innovative ways (p.143). One of the 'outcomes' for technology is that pupils should be able to understand and apply technological processes to solve problems and satisfy needs and wants (p.89).

Tytler and Swatton (1992:22) revealed that independent research projects are the main traditional vehicle for encouraging students to do their own investigation. In his ethnographic study to find out what year I-IV pupils think about science practical work, Denny and Chennell (1986:334) found that pupils consider science practical work to be useful only in the school context. They suggested that the value of science practical work to pupils depends on their involvement in personal discovery, in learning about the scientific method, in developing a sense of curiosity, and in acquiring confidence in devising strategies for problem-solving.

Duch (1996:328) stated:

“ I believe some of the important aspects of problem-based learning can be incorporated in a large class setting. The complex real-world problems may need to be structured with guiding questions added. Incorporating some group activities with class discussion and lecture will allow students to have the structure and support necessary in large classes, while at the same time challenging and motivating them to really understand and enjoy physics.”

It was therefore important to include in the survey instrument an item which encourages the teaching and learning of problem solving skills through self-teaching and self-discovery. Chetty (1998:2) corroborated this by stating:

“We in South Africa have developed Transformational OBE to serve our needs. The aim is to produce responsible adults with practical approach to life, and equipped with problem-solving skills. This will lead to the development of citizens who can contribute towards an efficient South Africa.”

Item 9

"Changing the curriculum to a compulsory basic syllabus plus many options (i.e. students do compulsory science modules and choose others freely and individually for their own personal relevance and pleasure)."

This is a recommendation of the South African Association of Teachers of Physical Science (1978:6 & 11) which stated that, *"A compulsory core-plus-options is strongly recommended. Options should revolve around regional interests."* National Education Policy Initiative (NEPI) (1992:26) and Gray (1997:402) supported this recommendation. Van der Linde *et al.* (1994: 51) emphasised that a new science curriculum should provide for the necessary differentiation of pupils into different streams at senior secondary level, that is, science for all and science for continuation.

NEPI (1992:71) advocated that for students wishing to pursue specialist science, a modular approach in the senior secondary curriculum could allow them to take *'double science'* at a higher level. The White Paper (RSA, 1995:22) states that curriculum choice, especially in the post-compulsory period, must be diversified in order to prepare increasing numbers of young people and adults with the education required by the economy and for further learning and career development.

There are still no clear policies on the format of school science and technology education after the compulsory years of education (grades 1-9). The Science Education Committee has not yet formulated clear policies on the format of school science and technology in grades 10-12. It is in this light that this item was included in the survey instrument.

Item 10

"Giving all pupils in the primary schools in South Africa much more basic science and technology than they receive presently."

The South African Association of Teachers of Physical Science document (1978:8) advocated that priority for science and technology education should be given to primary

science and junior secondary school science. NEPI (1992:71) also expressed the view that one option for improving science education would be making it a compulsory subject from Sub A (grade 1) to the end of compulsory schooling (grade 9). They maintain that the adoption of 'science for all' will raise general education standards.

UNESCO (1983:55) advocated that science teaching should find its way into the primary schools, not for intellectual reasons, nor in order to accumulate scientific facts, but to give children experience of research and discovery while at the same time developing technical skills.

The South African government has guaranteed free and compulsory education for the first ten years of schooling. It is therefore of outmost importance to put emphasis on primary science if any levels of scientific literacy are to be achieved before the first exit point which is the end of grade 9. The inclusion of this item in the survey instrument was based on these views.

Item 11

"All interested groups in South Africa should be consulted on how they think science can be improved in schools."

King and van de Berg (1991:15) supported this notion by suggesting that the designing of the curriculum should be given enough time in order to allow for planning, consultation, experimentation and implementation. The NEPI (1992:6) and South African Association of Teachers of Physical Science (1978:11) also supported this idea by suggesting that those representatives of industry and other employers of scientific manpower, and practising science teachers should be involved in the science curriculum development project. UNESCO (1983: 56) also stated that the reform of science curriculum requires the co-operation of many bodies.

This item was therefore included on these grounds.

Item 12

"Using computer-aided instruction and computer interfacing as part of science experiments. (For example, to display, analyse and plot data, and to explain science concepts)."

Hodson (1992:69) emphasised that by using a computer as a tool to find answers to their questions, students develop real problem-solving and inquiry skills. He also noted that computer assisted education not only developed a set of skills that are of value to the students (such as marketable skills for employment), but that these skills are also transferable to other learning contexts. He further stated that computers are also motivating to the students, and they also enable students to explore their theoretical understanding and conduct quick and reliable investigations (p.68).

The prospects of computer interfacing as an adjunct to a science experiment are endless, more so if the results are presented graphically (Gipps, 1994:48). Rogers and Wild (1994:21) also mentioned that the new tools based on information technology contribute greatly to the quality and depth of learning. Wilcox and Jensen (1997:261) argued that the versatility of computers and their many applications benefit males and females as well as students with various learning styles.

Item 13

"Promoting careers in science and technology among school pupils in South Africa."

The White Paper (RSA, 1995:30) mentioned that there is a need for finding criteria to prepare and recruit students for subjects in short supply, particularly science, mathematics and technology. SAQA (Department of Education, 1997:15) also emphasised that schooling should make students aware of the importance of exploring education and career opportunities.

Cumming (1990:33) mentioned that career guidance does not feature at all on formal school timetables in most African schools. She further pointed out that teachers tend to be unaware of specific opportunities available in the field of science and technology. The problem of career guidance for natural sciences in South Africa is further collaborated by Marais (1998:12). He stated that:

“One should be perturbed at how many high school students are unaware of careers in biotechnology, geology, metallurgy, ceramics technology, environmental management, food technology and many more other professions.”

Connelly *et al.* (1985: 139) emphasised that students should learn how science education can contribute to their eventual employment and to career possibilities, related to science and technology. Woolnough (1997:68) stated that,

“We need to ensure that enough of the most able students decide to continue with science into higher education and scientific and technological careers.”

Item 14

"Sharing and increasing the intellectual excitement and sense of adventure which science offers (such as its benefits, optimism, encouragement, spirit and challenge to the South African pupils)."

Fox (1982), Fisher (1983) and Kahle (1983) (all in Thomas, 1986:34) found that providing students with greater access to informal mathematics, science education and extra-curricular activities had been identified as an additional strategy for increasing their interest in mathematics and science.

Hodson (1992:76) suggested that science in schools must be exciting, challenging, and relevant to the experiences and the needs of the students. He further suggested that practical work should be planned in such a way that it provides all students with experience of success, thereby building their self-esteem and engendering the self-confidence needed to tackle other complex tasks, both in the science classroom and in the wider world outside (p.77).

Researchers such as Tytler and Swatton (1992), Lee (1997), Solbes and Vilches (1997), Maor and Fraser (1996), Woolnough (1997), Woolnough *et al.* (1997) and Drost *et al.* (1998) had all advocated the use of exciting and innovative ways for teaching science so as to cultivate interest and motivate the students towards science and technology inclination.

This item was included due to these recommendations.

Item 15

"Learning science through the African indigenous technology and culture, and through the African world view of life and thought systems. (i.e. preserving what is good in African culture and tradition, regarding science as sacred, learning science through African theories of space and time, the kinship system, customs, images, symbols, forms of expression, values, feelings and interpretations)."

The Department of Education (1997:143) recommended that at the end of schooling pupils should be able to demonstrate knowledge and understanding of the relationship between science and culture. Pupils should also be able to demonstrate an understanding of how different societies create and adapt technological solutions to particular problems (p.89).

Jegede and Okebukola (1989:141) studied socio-cultural factors that mitigate against drift towards science and technology in 707 secondary school science students in Nigeria. They found that factors such as authoritarianism, goal structure, the African world-view, societal expectations and sacredness of science have a significant effect on the learning of science. Jegede and Okebukola suggested that there is a need for a total overhaul of the Nigerian curriculum materials to reflect aspects of culture found to positively enhance science education, while at the same time address or eliminate areas which conflict with beliefs already held by learners (p.149).

Addo (1997:23) argues that research reveals that many African children subscribe to traditional beliefs to varying degrees and that these beliefs conflict with science learned.

Jegade and Okebukola (1989:148) emphasised that the learner's ideas need to be understood and his beliefs taken into account in teaching science, in order to forestall the drift away from science and technology.

Cumming (1990:30) argued that if it is desirable that the African embrace science and engineering, rather than mere technology, then teachers and lecturers must reach the root of the problem – the African's monistic world view - and try to modify it in a manner in which he can begin to regard nature apart from himself or other things. Baker (1996:19), Dlamini *et al.* (1996:222), Knamiller *et al.* (1995:74), Ogunniyi (1995:95), Amara (1987:317), Baker (1996:19), Spencer (1997:542) and Flear (1997:17) have also given several arguments in support of the use of indigenous technology in the teaching of science and technology.

2.6.2 The Validation of the instrument

Developmental pilot studies of potential instruments (Appendix 2) occurred in 1995 using critical research groups of post-graduate science and technology teachers in small-scale trials. In the first attempt at piloting the instrument, the respondents were asked to rank the items in order of perceived importance, but this proved to be cumbersome. The most practical outcome which emerged from the piloting was the suggestion to make just a simple headcount of all the 'agree' or 'disagree' responses for each item.

After trialling at three universities in South Africa fifteen categories of policy recommendations emerged, and these were carefully worded and selected as being immediately relevant to South African S-E-T education, and to the principles and values stated in the Government White Paper (RSA, 1995).

These statements of recommendations were then amplified and used from 1995-1997 to finalise the content of a seventeen item survey instrument, in order to gather data for science-technology-society policy formulation and prioritisation as part of the new Government of National Unity's Reconstruction and Development Programme. The

statements were amplified to give more clarification to their meaning so as to eliminate ambiguity.

Further recommendations received during the testing of the instrument led to the inclusion of an open-ended section in 1997 (Appendix 3a). Respondents were asked to give reasons for their choices of 'best/least' important recommendations, and to offer any other suggestions that might have been omitted from the instrument.

The instrument was adapted to be used for the collection of data in the North West Province by substituting 'South Africa' with 'North West Province' (Appendix 3b). The aim was to localise the instrument.

2.6.3 The reliability of the instrument

Initially, the reliability of the responses to the instrument was measured using an intact sample of volunteer science/technology teachers over a period of seven weeks. Test/re-test responses yielded reliability coefficients of $r = 0.97$, $r = 0.88$ and $r = 0.90$ ($N = 14$).

A second assessment of the reliability of the instrument and the stability of the responses was made in 1997 using an intact class of grade 11 science pupils whose home language is Xhosa over a period of seven days. Test/retest scores yielded reliability coefficients of $r = 0.91$ and $r = 0.90$ ($N = 47$), for the Xhosa version of the instrument (see Appendix 4).

2.6.4 Questionnaire Design

Literature for questionnaire design was consulted. Technical directives, checks and balances offered by survey research questionnaire practitioners Cohen and Manion (1985), and Wiersma (1991) were used. Throughout the piloting up to the final survey instrument more attention was taken on the following: -

1. Readability.
2. Clear and concise instructions.

3. Length of the questionnaire.
4. Layout.
5. Clarity of the statements.
6. Apparent duplication.

The first section of the questionnaire is a biographical data. The second section of the instrument required respondents to say whether they *'agree'* or *'disagree'* with each of the fifteen recommendations offered for improving the teaching and learning of school science/technology curriculum programmes. They indicated their choice of each item by making a circle on the 'A' (*agree*) or 'B' (*disagree*). The final two items requested the respondents to focus on, and select, the *'two best'* ways for improving school science/mathematics/technology in the new South Africa; and to identify the *'two least important'* recommendations of the fifteen.

The last section was open-ended. It required respondents to give reasons for their two choices of *'best'* and *'least'* important recommendations. This section further asked the respondents for any further suggestion that might be included for the improvement of teaching and learning of science and technology.

2.7 Chapter Summary

This chapter was divided into Part A and Part B.

In Part A, the following were discussed: -

- In section 2.1, a brief overview was presented of the current status of school science and technology education in South Africa. Their implications for the development of the instrument were stated.
- Section 2.2 reviewed the aims and objectives of the envisaged 'curriculum 2005' for science and technology. Their implications for the development of the survey instrument stated.
- Finally, in Section 2.3, a review was made of the recent trends in science and

technology education in different countries.

Part B recorded the wording of each of the 15 items comprising the survey instrument, and explained the related literature used for designing the survey research instrument more explicitly and comprehensively. The instrument validity, reliability and design were also presented.

The next chapter presents the research methodology in detail.

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CHAPTER 3

RESEARCH METHODOLOGY

The methodological aspects described in this chapter are:

- 3.1 The survey research method.
- 3.2 The samples and context.
- 3.3 Procedures for data collection.
- 3.4 Data capturing and analysis.
- 3.5 Statistical method.
- 3.6 Chapter summary.

3.1 The survey research method

Survey sampling is the research method used in this study. It was found to be the only research method suitable for this kind of study since it could be used to gather data from a relatively large number of cases at a particular time (Ary and Jacobs, 1979:25, Cohen and Manion, 1985: 94). Surveys are used to measure attitudes, opinions or achievements in a natural setting (Wiersma, 1991:165). Fink and Kosecoff (1985:5) regard it as a rediscovered strategy for science education research.

A self-completion 17 item questionnaire (Appendix 3a and 3b) was used for collecting data. The use of a paper and pencil questionnaire is widely employed in educational research (Ary *et al.* 1979:194) as it is regarded as more efficient and practical, and allows for the use of a larger sample than interviews. Further advantages of this technique are that standard instructions are given to all subjects; and the personal appearance, mood, or conduct of the investigator will not influence the results. There are limitations to this kind

of research method and these will be discussed in chapter 6. The questionnaire was administered through mail and self-administered.

Literature for conducting survey research was consulted in order to formulate the research design (Cohen and Manion, 1985; Fink and Kosecoff, 1985; Wiersma, 1991; and Fowler, 1993). Cluster sampling of accessible samples was used in this study and, since random sampling was not done, the sampling could be described as non-probability. The different procedures used for administering the questionnaire are discussed under section 3.3.

3.2 The samples and their context

Sample 1 consisted of 134 rural/semi-rural high school science teachers from the eastern region of the North West Province of South Africa. About 96% speak Setswana as their first language and English as a second language. There was an approximately equal distribution of males and females with an age range from 25-55 years.

The North West Department of Education and Culture is administered through 12 districts. The eastern district areas under investigation in this study are Brits, Mabopane and Temba. According to the Education Foundations (1997:4) survey, North West has a total of 1 595 science teachers of whom only 47% have science qualifications and 84% are professionally qualified. This agrees with a survey by the South African Institute of Race relations (1997:18) which also found that the North West Province had the highest proportion of under-and-unqualified teachers, i.e. 48% of its total teacher population. The area surveyed consisted of about 40 high schools of which 75% are in rural areas and the rest in the townships.

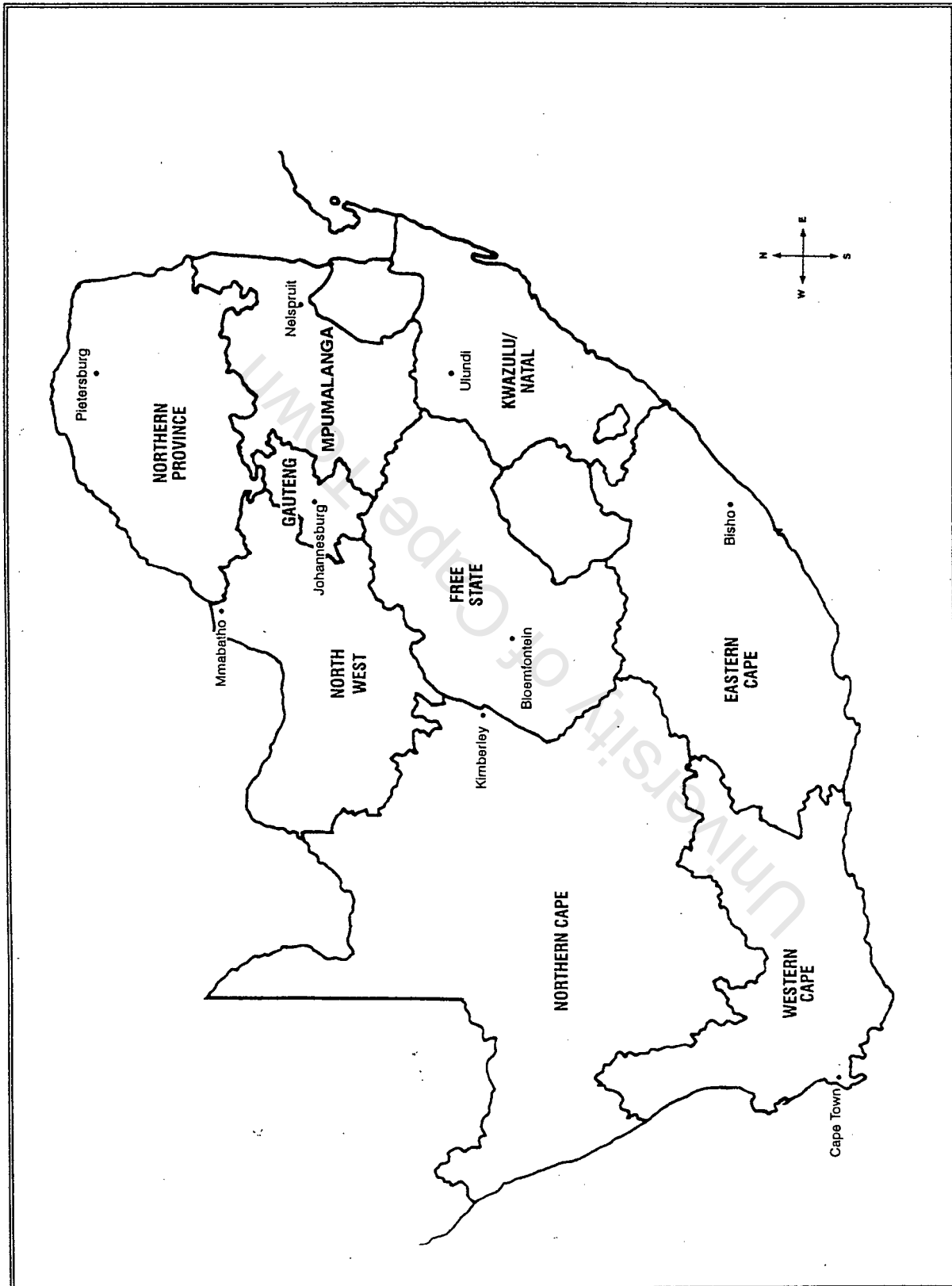
Sample 2 consisted of 200 high school science Expo students who participated in the 1997 national Expo competition held at the University of Pretoria in Gauteng Province. The students were regional winners who came from the different regions in the Republic

of South Africa, with the majority from the urban areas of each of the nine provinces. Their ages ranged from 15 - 19 years, and almost all were fluent speakers of English.

The South African Expo for Young Scientists was founded in 1980 and was based on the School Science Fair movement that was an integral part of the United States Information Service (USIS) (Drost *et al.*, 1998:10). In this country, Expo has developed a considerable international recognition as a member of Mouvement International pour le Scientifique et Technique (MILSET) International Youth Science Movement that is based in Paris. Expo expects entrants to present the products of their scientific and technological enquiries for evaluation and judging. There are now 36 Expo regions in South Africa that organise annual regional Expo's. The finalists from these regions are sent to the National Expo Finals held at the University of Pretoria every year.

Sample 3 consisted of 75 high school science Expo students from Cape Town who participated in the 1997 science Expo held at the University of Cape Town. These were the annual science Expo regional competition entrants from the Western Cape Province. About 90% of the entrants spoke English as a first language and 10% spoke Xhosa as their first language and English as a second language. Their ages ranged from 15- 19 years.

Figure 3.1 depicts the geographical locations of the samples.



3.3 Procedures for data collection

3.3.1 Sample 1 (Setswana-speaking science teachers)

Data was collected during the period May-August 1997 from the science teachers in the North West by the normal mailing system used by the education circuit managers. In all the education circuit offices each school belonging to that circuit is allocated a letterbox in the education office. This letterbox is used to send information from the department of education to schools. The school principals normally collect the correspondence at least once a week. Correspondence that is brought back from the schools is submitted to the administration officer who in turn distributes it to the relevant education department offices. The distribution of questionnaires was done as part of the researcher's employment duties as it was a common procedure for her to send support material and correspondence to the science teachers.

Since the statistics of the actual number of science teachers in each school was not available to the researcher, a list of the total number of teachers in each school was used to estimate the number of questionnaires to be sent to each school. A total of 180 questionnaires (2-5 questionnaires per school) were sent. The questionnaires, a covering letter, and an extra envelope addressed to the department to which the responses should be sent were put in an envelope which was addressed to each school. The policy of each education circuit office specifies that a copy should be made available of any correspondence to the schools, and this was followed.

Two weeks after the distribution of questionnaires, the researcher had to remind the circuit education managers to ask the school principals to bring the questionnaires from the schools. This was done telephonically at least once a week for four weeks. Reminders to the principals was done through notices placed on the notice board in each education circuit office and also verbally. These reminders were written and monitored by the education circuits' staff. A great deal of co-operation by both the administration staff and the education managers was needed during the data collection period.

3.3.2 Sample 2 (Pretoria science Expo students)

Data was collected in October 1997 on the first day of the national science Expo during judging. The questionnaires were administered personally by the researcher with the help of an enthusiastic assistant. Four weeks before the collection of data the researcher asked for permission to conduct the survey from the national Expo organising committee. A letter that explained the aims of the research, the research topic together with the survey instrument was sent to the committee. Permission was granted to collect the data on the first day of the science Expo.

Questionnaires were distributed to the students and collected after ten minutes. The students who were busy with the Expo judges, or who were still organising their projects, were given the questionnaire later. Only those who were willing to participate in the study were given the questionnaire in the language of their choice. Only five students out of 235 declined to take part, saying that they were “too busy” at that particular time they were approached individually. Students were free to answer the open-ended section of the questionnaire in any language.

Most students preferred to answer the questionnaire in English, although about 2% requested an Afrikaans questionnaire for language clarification. About 4% answered the open-ended section in Afrikaans. Two hundred and twenty (220) questionnaires were issued, 208 returned and eight were spoilt. The 12 who did not return their questionnaires claimed “tiredness after undergoing the judging process” as their reason for declining.

3.3.3 Sample 3 (Cape Town science Expo students)

Data was collected in August 1997 during judging on the first day of the regional science Expo competition at the University of Cape Town. The science education unit staff of this university helped to administer the questionnaires.

Questionnaires were distributed to the students and collected after ten minutes. Students who were busy with the Expo judges, or who were still organising their projects, were given the questionnaire later. Only those who expressed willingness to participate in the study (i.e. almost all the pupils who were approached) were given the questionnaire in the language of their choice. Students were free to answer the open-ended section of the questionnaire in any language.

All students preferred to answer the questionnaire in English. Ninety questionnaires were issued and 75 were completed.

3.4 Data capture and analysis

Quantitative data

A frequency count of the responses to the 17-item data-capturing instrument was first employed and data was stored in Microsoft Excel 5 software programme in the form of tables (i.e. a *agree* and *disagree* response table, and a *best* and *least important recommendations* table).

Qualitative data

The qualitative data was also captured using Microsoft Excel 5 Software. Statements with the same meaning were then grouped together, and a frequency count was undertaken. Suggestions and explanations where fewer than five people supported a certain recommendation, and also where fewer than five people opposed the same recommendation were not reported on in detail.

3.5 Selection of statistical methods

A chi-square (χ^2) test for two independent groups was used to test the six null hypotheses. This was contained in a Statgraphics computer package. In tables where the frequencies in a cell were less than five, Fisher's exact probability test was used. These are non-parametric tests.

Chi square (χ^2) test for a two-by-two arrangement

Statgraphics package for calculating contingency tables in a two-by-two arrangement was used to test null hypotheses 1a, 1b, 2a, 2b, 3a and 3b. The data in contingency tables has an advantage because it can be used with the following types of data: continuous data, data in ordered scales, and data in unordered groups or dichotomous (Selkirk, 1983:5). The chi square test has the same logic as the more advanced multivariable procedures (Reynolds, 1993).

The formula used for calculating chi square (χ^2) is: -

$$\chi^2 = \frac{N(ad - bc)^2}{(a + b)(a + c)(b + d)(c + d)} \quad \text{with 1 df}$$

a, b, c and d are the four observed frequencies
N = a + b + c + d is the sample size

The test is a two-tailed test with one degree of freedom. The following critical chi square values are read from the table F: 3.84 (5% level) and 6.64 (1% level). The Statgraphics programme calculates the chi square value with Yates' correction. This correction only applies in the case of 2 x 2 contingency tables with one degree of freedom and reduces the obtained value of chi-square by 0.5.

Restrictions on the use of chi square (χ^2) in a 2 x 2 table

Even when Yates' correction has been made, it is not advisable to use the test when the expected frequency (f_e) is less than 5 because low denominators have a large effect on the value of χ^2 (Selkirk 1983:18).

3.6 Chapter summary

All the aspects of the research methodology followed in this research have been discussed in this chapter, namely: the selection of the research method (survey); a description of the three samples and their context; the practical details implemented in the collection of the data from the respondent groups; data capture; and the choice of statistical tools and techniques for the data analysis. The results and findings of the research study follow on in **Chapter 4**.

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CHAPTER 4

RESULTS AND FINDINGS

In this chapter, only the results of the three surveys and a summary of the findings for the six hypotheses are presented. A comprehensive discussion of the findings occurs later, in a subsequent chapter, following the presentation of the overall patterns of results in this chapter.

4.1 The empirical findings : overall trends

4.1.1 The Setswana-speaking science teachers (n = 134) (sample 1)

The results summarising the response frequencies of agreement/disagreement by the 134 Setswana-speaking science teachers in 1997 are presented in Table 4.1 on page 50. In terms of an ordinal scale the two science, engineering and technology (S-E-T) policy recommendations gaining the highest degree of consensus for science curriculum design and reconstruction were found to be: -

- (1) Introducing more real life skills in science ; and*
- (8) Making more use of self discovery in science.*

The two most frequently rejected S-E-T policy suggestions were: -

- (2) Paying more attention to gender issues in science; and*
- (5) Paying more attention to language in science.*

Table 4.1 also presents the major policy issues selected by the Setswana-speaking science teachers as the most important and least important of the fifteen presented for their consideration.

The two most highly favoured curriculum recommendations again were: -

- (1) Introducing more real life skills in science; and*
- (8) Making more use of self-discovery and self-teaching in science.*

The two least important science and technology curriculum policy issues were: -

- (2) Paying more attention to gender issues in science; and*
- (5) Paying more attention to language in science.*

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Table 4.1: The frequency scores and priorities of the 15 science and technology curriculum policy issues by the Setswana-speaking science teachers (N = 134) in 1997.

Suggestions for improvement	Response Frequencies			
	Agree	Disagree	Best Recommendation	Least Important
1. More real life skills in science	131	3	56	2
2. More gender issues in science	43	91	0	65
3. More environmental issues	108	27	9	14
4. Science for community development	111	23	10	10
5. More attention to language	52	82	2	58
6. More focus on the disadvantaged	107	28	6	8
7. More competitions in science	125	9	23	3
8. More self-discovery in science	131	3	48	6
9. Core plus options curriculum	105	29	21	9
10. More primary school set	127	7	34	0
11. Wider community consultations	130	4	7	11
12. Computer-aided science	125	9	21	5
13. Promoting careers in science	73	61	10	7
14. Excitement and adventure	126	8	6	7
15. African indigenous science	73	61	5	48
Item ordinal ranking :-	1 No. 1	No. 2	No. 1	No. 2
	2 No. 8	No. 5	No. 8	No. 5

4.1.2 The Pretoria science Expo students (N = 200) (sample 2)

Table 4.2 on page 52 presents the summary of the results obtained from the frequencies of the 15 science, engineering and technology (S-E-T) curriculum policy recommendations by the Pretoria science Expo students (N = 200) in 1997. In terms of the item ordinal ranking, the S-E-T policy recommendations gaining the highest degree of consensus for science curriculum design and reconstruction were found to be: -

- (1) *Providing more real life skills in science ;*
- (7) *Encouraging more competitions in science;*
- (8) *Making more use of self- discovery and self-teaching in science;*
- (13) *Promoting careers in science and technology among school pupils in South Africa; and*
- (14) *Sharing and increasing the intellectual excitement and sense of adventure which science offers.*

The most frequently rejected science, engineering and technology curriculum policy suggestions were: -

- (5) *Paying more attention to language issues in science; and*
- (15) *Learning science through African indigenous science, technology and culture, and through the African world view of life and thought systems .*

Table 4.2 also presents the major policy recommendations selected by the Pretoria science Expo students as the most important/least important of the fifteen science, engineering and technology policy recommendations presented for their consideration.

The two recommendations favoured as the most important were: -

- (1) *Providing more real life skills in science ; and*
- (8) *Making more use of self-discovery and self-teaching in science;*

The two least important recommendations identified among the 15 were: -

- (2) *Paying more attention to gender issues in science; and*
- (5) *Paying more attention to language issues in science.*

Table 4.2: The frequency scores and priorities of the 15 science and technology curriculum policy issues by the Pretoria science Expo students (N = 200) in 1997

Suggestions for improvement	Response Frequencies			
	Agree	Disagree	Best Recommendation	Least Important
1. More real life skills in science	182	18	75	9
2. More gender issues in science	89	111	2	80
3. More environmental issues	175	25	24	6
4. Science for community development	159	41	24	16
5. More attention to language	92	108	8	86
6. More focus on the disadvantaged	132	68	10	29
7. More competitions in science	184	16	55	4
8. More self-discovery in science	182	18	56	12
9. Core plus options curriculum	125	75	20	20
10. More primary school set	163	37	29	18
11. Wider community consultations	174	26	7	10
12. More computer-aided science	169	31	27	10
13. Promoting careers in science	182	18	18	7
14. Excitement and adventure	184	16	29	9
15. African indigenous science	72	128	6	76
Item ordinal ranking :-	1 Nos. 7/14	No. 15	No. 1	No. 5
	2 Nos. 1/8/13	No. 2/5	Nos. 8/7	No. 2

4.1.3 The Cape Town science Expo students (N = 75) (sample 3)

The results of the frequencies of responses to the 15 science, engineering and technology curriculum policy recommendations by the Cape Town science Expo students (sample 3) (N = 75) in 1997 are presented in Table 4.3 on page 54.

In the item ordinal ranking of the individual total frequencies for the 15 items, the suggestions receiving the highest consensus for science curriculum design and reconstruction were found to be: -

- (1) *Providing more real life skills in science; and*
- (14) *Sharing and increasing the intellectual excitement and sense of adventure which science offers.*

The most rejected S-E-T policy recommendations were found to be: -

- (5) *Paying more attention to language issues in science; and*
- (15) *Learning science through African indigenous science, technology and culture, and through the African world view of life and thought systems .*

Table 4.3 also presents the frequencies of the responses of the most important/least important science, engineering and technology curriculum issues chosen from the 15 recommendations presented to the 75 Cape Town science Expo students.

The two most favoured recommendations were: -

- (1) *Providing more real life skills in science; and*
- (12) *Using computer- aided instruction and computer interfacing as part of science experiments. .*

The two least important recommendations identified among the 15 were: -

- (2) *Paying more attention to gender issues in science; and*
- (5) *Paying more attention to language issues in science.*

Table 4.3: The frequency scores and priorities of the 15 science and technology curriculum policy issues by the Cape Town science Expo students (N = 75) in 1997

Suggestions for improvement	Response Frequencies			
	Agree	Disagree	Best Recommendation	Least Important
1. More real life skills in science	64	11	21	0
2. More gender issues in science	51	20	0	13
3. More environmental issues	54	18	8	5
4. Science for community development	57	17	6	2
5. More attention to language	26	43	0	20
6. More focus on the disadvantaged	47	25	3	6
7. More competitions in science	53	19	7	4
8. More self-discovery in science	57	14	9	2
9. Core plus options curriculum	37	23	7	5
10. More primary school set	60	13	9	1
11. Wider community consultations	56	16	1	2
12. Computer-aided science	54	18	12	5
13. Promoting careers in science	56	15	4	4
14. Excitement and adventure	65	7	2	0
15. African indigenous science	30	39	0	6
Item ordinal ranking :-				
1	No. 14	No. 5	No. 1	No. 5
2	No. 1	No. 15	No. 12	No. 2

The overall conclusion drawn from these three tables of findings is that, by consensus, the most commonly accepted recommendations for science curriculum design and reconstruction were: -

- (1) Providing more real life skills in science (samples 1, 2 & 3);
- (8) Making more use of self discovery in science (samples 1 & 2) and
- (14) Sharing and increasing the intellectual excitement and sense of adventure which science offers (samples 2 & 3).

The most commonly rejected recommendations were: -

- (2) Paying more attention to gender issues in science (samples 1 & 2);
- (5) Paying more attention to language issues in science (samples 1 & 2) and
- (15) Learning science through African indigenous science, technology and culture, and through the African world view of life and thought. (samples 2 & 3).

The two recommendations favoured as the most important among the 15 by all three, or by two, of the samples were: -

- (1) Providing more real life skills in science (samples 1, 2 & 3) and
- (8) Making more use of self discovery in science (samples 1 & 2).

The two recommendations rated as least important among the 15 by all three samples were: -

- (2) Paying more attention to gender issues in science (samples 1, 2 & 3) and
- (5) Paying more attention to language issues in science; (samples 1, 2 & 3).

4.2 The null hypotheses testing

In this section, the responses of samples 1, 2 and 3 are compared in pairs for each of the 15 science, engineering and technology (S-E-T) curriculum policy recommendations.

4.2.1 Setswana-speaking science teachers (N = 134) (sample 1) versus Pretoria science Expo students (N = 200) (sample 2)

H₀1a There will no significant difference between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 200 Pretoria science Expo students (sample 2) in their frequencies of agreement/disagreement with each of the 15 proposed science, and technology policy recommendations.

The chi-square values recorded in Table 4.4 on page 57 for each of the 15 science and technology policy recommendations indicate that the null hypothesis is not rejected for items 3-5; 7; 10 and 14, but rejected for items 1; 2; 6; 8 and 12 at the 95% level of confidence ($p < 0,05$), and rejected for items 9; 11; 13 and 15 at the 99% level of confidence ($p < 0,01$).

H₀1b There will no significant difference between the responses of the 134 Setswana-speaking science teachers (sample 1) and the 200 Pretoria science Expo students (sample 2) in their frequencies of best/least important priority for each of the 15 proposed science and technology policy recommendations.

The chi-square values recorded in Table 4.5 on page 58 for each of the 15 science and technology policy recommendations indicate that the null hypothesis is not rejected for items 1-2 and 4-15, but is rejected for items 3 and 10 at the 99% level of confidence ($p < 0,01$).

Table 4.4: A comparison of the agree/disagree responses to the 15 S&T policy curriculum recommendations by the Setswana-speaking science teachers (N = 134) (sample 1) and the Pretoria science Expo students (N = 200) (sample 2)

RESPONSE FREQUENCIES						
Suggestions for improvement	Setswana-speaking science teachers (N = 134)		Pretoria science Expo students (N = 200)		Chi-square	p-value
	Agree	Disagree	Agree	Disagree		
1. More real life skills in science	131	3	182	18	5,13	0,02*
2. More gender issues in science	43	91	89	111	4,66	0,03*
3. More environmental issues	108	27	175	25	2,90	0,09
4. Science for community development	111	23	159	41	0,38	0,54
5. More attention to language	52	82	92	108	1,41	0,23
6. More focus on the disadvantaged	107	28	132	68	6,30	0,01*
7. More competitions in science	125	9	184	16	0,05	0,82
8. More self-discovery in science	131	3	182	18	5,13	0,02*
9. Core plus options curriculum	105	29	125	75	8,69	0,00**
10. More primary school set	127	7	163	37	11,22	0,00**
11. Wider community consultations	130	4	174	26	8,66	0,00**
12. Computer-aided science	125	9	169	31	5,07	0,02*
13. Promoting careers in science	73	61	182	18	57,26	0,00**
14. Excitement and adventure	126	8	184	16	0,23	0,63
15. African indigenous science	73	61	72	128	10,4	0,00**

df = 1; Chi-square (χ^2) values read from Table F: 3,84 (5% level) = 95% confidence
6,64 (1% level) = 99% confidence

* $p < 0,05$ – Indicates a significant difference between samples 1 & 2 for a certain item

** $p < 0,01$ – Indicates a highly significant difference between samples 1 & 2 for a certain item

Table 4.5: A comparison of the best/least important responses to the 15 S&T policy curriculum recommendations by the Setswana-speaking science teachers (N = 134) (sample 1) and the Pretoria science Expo students (N = 200) (sample 2)

RESPONSE FREQUENCIES						
Suggestions for improvement	Setswana-speaking science teachers (N = 134)		Pretoria science Expo students (N = 200)		Chi-square	p-value
	Best choice	Least choice	Best choice	Least choice		
1. More real life skills in science	56	2	75	9	1,62	0,20
2. More gender issues in science	0	65	2	80		
3. More environmental issues	9	14	24	6	7,60	0,00**
4. Science for community development	10	10	24	16	0,21	0,65
5. More attention to language	2	58	8	86	0,88	0,35
6. More focus on the disadvantaged	6	8	10	29	0,75	0,39
7. More competitions in science	23	3	55	4	0,09	0,76
8. More self-discovery in science	48	6	56	12	0,57	0,45
9. Core plus options curriculum	21	9	20	20	2,06	0,15
10. More primary school set	34	0	29	18		0,00#
11. Wider community consultations	7	11	7	10	0,00	1,00
12. Computer-aided science	21	5	27	10	0,17	0,67
13. Promoting careers in science	10	7	18	7	0,30	0,57
14. Excitement and adventure	6	7	29	9	2,80	0,09
15. African indigenous science	5	48	6	76	0,01	0,91

df = 1; Chi-square (χ^2) values read from Table F: 3, 84 (5% level) = 95% confidence
6, 64 (1% level) = 99% confidence

* $p < 0, 05$ – Indicates a significant difference between samples 1 & 2 for a certain item

** $p < 0, 01$ – Indicates a highly significant difference between samples 1 & 2 for a certain item

- Indicates Fisher's exact probability test

Table 4.6: A comparison of the agree/disagree responses to the 15 S&T curriculum policy recommendations by the Setswana-speaking science teachers (N= 134) (sample 1) and the Cape Town science Expo students (N = 75) (sample 3)

RESPONSE FREQUENCIES						
Suggestions for improvement	Setswana-speaking science teachers (N = 134)		Cape Town science Expo students (N = 75)		Chi-square	p-value
	Agree	Disagree	Agree	Disagree		
1. More real life skills in science	131	3	64	11	9,97	0,00**
2. More gender issues in science	43	91	51	20	27,90	0,00**
3. More environmental issues	108	27	54	18	0,42	0,51
4. Science for community development	111	23	57	17	0,70	0,40
5. More attention to language	52	82	26	43	0,00	1,00
6. More focus on the disadvantaged	107	28	47	25	4,11	0,04*
7. More competitions in science	125	9	53	19	13,80	0,00**
8. More self-discovery in science	131	3	57	14	16,40	0,00**
9. Core plus options curriculum	105	29	37	23	5,06	0,02*
10. More primary school set	127	7	60	13	7,19	0,00**
11. Wider community consultations	130	4	56	16	17,60	0,00**
12. Computer-aided science	125	9	54	18	12,19	0,00**
13. Promoting careers in science	73	61	56	15	10,80	0,00**
14. Excitement and adventure	126	8	65	7	0,50	0,48
15. African indigenous science	73	61	30	39	1,79	0,18

df = 1; Chi-square (χ^2) values read from Table F: 3, 84 (5% level) = 95% confidence
6, 64 (1% level) = 99% confidence

* $p < 0, 05$ – Indicates a significant difference between samples 1 & 3 for a certain item

** $p < 0, 01$ – Indicates a highly significant difference between samples 1 & 3 for a certain item

Table 4.7: A comparison of best/least important responses to the 15 S&T curriculum policy recommendations by the Setswana-speaking science teachers (N = 134) (sample 1) and the Cape Town science Expo students (N = 75) (sample 3)

RESPONSE FREQUENCIES						
Suggestions for improvement	Setswana-speaking science teachers		Cape Town science Expo students		Chi-square	p-value
	(N = 134)		(N = 75)			
	Best choice	Least choice	Best choice	Least choice		
1. More real life skills in science	56	2	21	0		
2. More gender issues in science	0	65	0	13		
3. More environmental issues	9	14	8	5	0,89	0,34
4. Science for community development	10	10	6	2	0,62	0,43
5. More attention to language	2	58	0	20		
6. More focus on the disadvantaged	6	8	3	6	0,00	0,98
7. More competitions in science	23	3	7	4	1,70	0,19
8. More self-discovery in science	48	6	9	2	0,02	0,88
9. Core plus options curriculum	21	9	7	5	0,13	0,72
10. More primary school set	34	0	9	1		
11. Wider community consultations	7	11	1	2	0,00	1,00
12. Computer-aided science	21	5	12	5	0,16	0,67
13. Promoting careers in science	10	7	4	4	0,00	1,00
14. Excitement and adventure	6	7	2	0		
15. African indigenous science	5	48	0	6		

df = 1; Chi-square (χ^2) values read from Table F: 3,84 (5% level) = 95% confidence
6,64 (1% level) = 99% confidence

* $p < 0,05$ – Indicates a significant difference between sample 1 & 3 for a certain item

** $p < 0,01$ – Indicates a highly significant difference between sample 1 & 3 for a certain item

4.2.3 Pretoria science Expo students (N = 200) (sample 2) versus Cape Town science Expo students (N = 75) (sample 3)

H₀3a There will be no significant difference between the responses of the 200 Pretoria science Expo students (sample 2) and the 75 Cape Town Expo students in their frequencies of agreement/disagreement for each of the 15 proposed science and technology policy recommendations.

The chi-square values recorded in Table 4.8 on page 63 for each of the 15 proposed science and technology curriculum recommendations indicate that the null hypothesis is not rejected for the items 1; 4-6; 9-12; 14-15, but is rejected for items 3; 8; 13 at the 95% level of confidence ($p < 0, 05$) and is rejected for items 2 and 7 at the 99% level of confidence ($p < 0, 01$).

H₀3b There will be no significant difference between the responses of the 200 Pretoria science Expo students (sample 2) and the 75 Cape Town science Expo students in their frequencies of best/least important choice for each of the 15 proposed science and technology curriculum policy recommendations.

The chi-square values on Table 4.9 on page 64 for each of the 15 proposed science and technology curriculum recommendations indicate that the null hypothesis is not rejected for items 1-5 and 7-15, but is rejected for item 6 at the 95% level of confidence ($p < 0,05$).

A detailed interpretation of these nine tables of findings, and the results of the six null hypotheses, are discussed more fully in the chapter which follows this one (i.e. Chapter 5). The remainder of this chapter is devoted to a presentation of the major qualitative findings and results, commencing on page 65.

Table 4.8: A comparison of the agree/disagree responses to the 15 S &T curriculum policy recommendations by the Pretoria science Expo students (N = 200) (sample 2) and the Cape Town science Expo students (N = 75) (sample 3)

RESPONSE FREQUENCIES						
Suggestions for improvement	Pretoria science Expo students (N = 200)		Cape Town science Expo students (N = 75)		Chi-square	p-value
	Agree	Disagree	Agree	Disagree		
1. More real life skills in science	182	18	64	11	1,30	0,25
2. More gender issues in science	89	111	51	20	14,5	0,00**
3. More environmental issues	175	25	54	18	5,3	0,02*
4. Science for community development	159	41	57	17	0,08	0,78
5. More attention to language	92	108	26	43	1,12	0,25
6. More focus on the disadvantaged	132	68	47	25	0,00	1,00
7. More competitions in science	184	16	53	19	14,37	0,00**
8. More self-discovery in science	182	18	57	14	4,80	0,03*
9. Core plus options curriculum	125	75	37	23	0,00	1,00
10. More primary school set	163	37	60	13	0,00	1,00
11. Wider community consultations	174	26	56	16	2,78	0,10
12. Computer-aided science	169	31	54	18	2,62	0,11
13. Promoting careers in science	182	18	56	15	6,12	0,01*
14. Excitement and adventure	184	16	65	7	0,04	0,84
15. African indigenous science	72	128	30	39	0,92	0,34

df = 1; Chi-square (χ^2) values read from Table F: 3, 84 (5% level) = 95% confidence
6, 64 (1% level) = 99% confidence

* $p < 0, 05$ – Indicates a significant difference between samples 2 & 3 for a certain item

** $p < 0, 01$ – Indicates a highly significant difference between samples 2 & 3 for a certain item

Table 4.9: A comparison of best/least important responses to the 15 S&T curriculum policy recommendations by the Pretoria science Expo students (N = 200) (sample 2) and the Cape Town science Expo students (N = 75) (sample 3)

RESPONSE FREQUENCIES						
Suggestions for improvement	Pretoria science Expo students (N = 200)		Cape Town science Expo students (N = 75)		Chi-square	p-value
	Best choice	Least choice	Best choice	Least choice		
1. More real life skills in science	75	9	21	0	1,28	0,26
2. More gender issues in science	2	80	0	13		
3. More environmental issues	24	6	8	5	0,79	0,37
4. Science for community development	24	16	6	2	0,16	0,68
5. More attention to language	8	86	0	20		
6. More focus on the disadvantaged	10	29	3	6	0,00	0,96
7. More competitions in science	55	4	7	4	5,36	0,02*
8. More self-discovery in science	56	12	9	2	0,00	1,00
9. Core plus options curriculum	20	20	7	5	0,03	0,86
10. More primary school set	29	18	9	1	1,83	0,16
11. Wider community consultations	7	10	1	2	0,00	1,00
12. More computer-aided science	27	10	12	5	0,00	1,00
13. Promoting careers in science	18	7	4	4	0,51	0,47
14. Excitement and adventure	29	9	2	0		
15. African indigenous science	6	76	0	6		

df = 1; Chi-square (χ^2) values read from Table F: 3, 84 (5% level) = 95% confidence
6, 64 (1% level) = 99% confidence

* $p < 0, 05$ – Indicates a significant difference between samples 2 & 3 for a certain item

** $p < 0, 01$ – Indicates a highly significant difference between samples 2 & 3 for a certain item

4.3 Qualitative findings

4.3.1 A summary of reasons given for the choice of best or least important items

This section presents a combined summary of the reasons given for the best/least important item choices made by the Setswana-speaking science teachers, Pretoria science Expo students and Cape Town science Expo students. Of the 409 respondents 226 responded to the open-ended section of the questionnaire. Samples of the respondents' hand-written reasons and suggestions have been photocopied and collated, and are attached in APPENDIX 5 as source material.

Introducing more real life skills into science (item 1)

The following were six recurring comments given by 65 respondents who were in favour of item 1:

- The introduction of real life skills prepares students for life after school by giving them real life experiences.
- Teaching using real life skills is more relevant and real, and will therefore make science more interesting.
- Science teaching and learning using real life skills will assist in future employment for those students who cannot proceed to tertiary level.
- Introducing more real life skills in science will encourage early career choices.
- Teaching science in this manner will make scientific ideas easier to understand and remember.
- The introduction of more real life skills into science will be the best way of teaching and learning science as it encourages students and teachers to do more practical work.

Paying more attention to gender issues (item 2)

Seventy respondents rejected item 2; all expressing the view that gender is not an issue in science. The main reason given was that in South Africa there is no discrimination between men and women as scientists and to emphasise this recommendation for improving the teaching and learning of science curriculum is a waste of time.

Paying more attention to language issues in science (item 5)

The following three reasons were commonly given by 60 respondents who commented against item 5: -

- Concentrating more on this recommendation will not make us more competitive internationally.
- Mother-tongue teaching in science will introduce its own additional particular problems of terminology and literature.
- English is already recommended as a standard language of communication in science, both nationally and internationally.

However, three respondents who supported item 5 emphasised the opposite opinion that mother-tongue teaching *would* improve understanding of science in pupils.

Encouraging competitions in science (item 7)

The following were the common reasons given by 40 respondents who supported item 7:

- Competitions create interest and enthusiasm to learn science.
- They encourage students to be their best.
- They stimulate students to work harder.
- They can raise or improve standards.
- Competitions can be fun.
- They encourage scientific creativity.

No qualitative comments were offered as reasons for opposing item 7.

Making more use of self-discovery and self-teaching (item 8)

The following were seven reasons frequently given by 56 respondents who commented in favour of item 8:

- These learning methods cultivate an interest in and understanding of science.
- For many pupils, the best way of learning is through experience.
- Self-discovery and self-teaching encourage critical thinking.

- Self-discovery and self-teaching motivate the pupils and are therefore very valuable methods for improving the teaching and learning of science and technology curriculum.
- These teaching methods have the capability to develop problem-solving skills and creative thinking.
- Skills gained through self-teaching can be applied in future careers.
- Self-discovery and self-teaching help students to realise their talents.

Four respondents who opposed item 8, however, expressed a concern that students do not always have the necessary knowledge to teach themselves.

Changing curricula to a compulsory basic syllabus plus options (item 9)

Eleven respondents were in favour of item 9, and all expressed the following view: -

- Studying an aspect of science in which one has an interest will increase motivation.

Eight respondents who opposed item 9 gave the following common reason:-

- Some people are not interested in science and therefore it cannot be made compulsory.

Giving pupils in the primary schools in South Africa much more science and technology (item 10).

The following is a summary of the comments made by the 24 respondents who supported item 10:

- If this recommendation is implemented, pupils in the primary school will receive the necessary applied knowledge of science, and this will arouse their interest.

The four respondents who opposed item 10, however, expressed the following concern: -

- More overcrowding of the primary school syllabi would be the result.

Using computer-aided instruction and computer interfacing as part of science experiments (item 12)

The following is a summary of the three reasons given by 26 respondents who commented in favour of item 12: -

- This teaching method will make science fun, enjoyable and easy to understand.
- Computer-aided instruction will encourage learning.
- Computer-aided instruction will make teaching and learning easier and interesting.

The following is a summary of the reasons given by seven respondents who wrote against item 12: -

- Computers are expensive – there are other needs that are more pressing than computers.

Promoting careers in science and technology among school pupils (item 13)

The following is a summary of the reasons given by nine respondents who supported item 13: -

- Career education is important in science because it prepares students for their future.

Sharing and increasing the intellectual excitement and sense of adventure, which science offers (item 14)

The following is a summary of the two reasons given by 13 respondents who commented in favour of item 13: -

- Students gain more knowledge by sharing ideas.
- Exciting experimental ideas will encourage more students to pursue science careers.

Learning through African indigenous technology and culture, and through the African world view and thought systems (item 15).

The following is a consensus summary of the written reasons given by 50 respondents who disagreed with item 15: -

- In their view, African culture is not related to science.
- In their opinion, it focuses towards a certain group of people and is therefore possibly discriminating against other cultural groups in South Africa.

4.3.2 Other suggestions and recommendations offered by 143 respondents: -

Resources

The following is a summary of the other written recommendations made by 69 respondents: -

- The government should make funding available for
 - (a) Physical resources, namely: - Building laboratories and libraries.
 - (b) Educational resources, namely: - Buying science equipment and constant servicing of it thereafter, buying textbooks, computers and equipping libraries.

Science campaigns

Eleven respondents also made the following recommendations: -

- There should be more campaigns on science and technology to try to make more people aware of its benefits and how it can enrich their lives.
- Also, more bursaries and scholarships should be offered to attract more students in these fields.

Learner support

The following summarises a common recommendation made by 28 respondents:

- There should be more excursions, field trips and visits to universities' science departments, industries, environmental sites and any other places of interest to do more practical work.

Teacher support

Thirty-five teachers from the sample recommended that there should be more teacher support in the form of: -

- Additional in-service courses
- Teacher upgrading programmes
- More science centres
- More science seminars
- More frequent science workshops.

4.3.3 Unreported items

No significant number of reasons were forwarded for the choice of best or least important policy recommendation for items 3, 4, 7 and 11.

4.4 Chapter summary

In this chapter it was reported that the responses obtained from the three samples were in agreement with regard to about half the number of curriculum policy recommendations suggested for South African school science. For the other half, statistically significant differences were found to occur among the three samples of respondents surveyed in 1997, with regard to their priorities for 15 suggested South African school science curriculum policy suggestions.

The qualitative findings of the survey have been presented with newly emerging suggestions focusing on supporting the science curriculum through more resources, science campaigns, visits to off-school sites and teacher support through programmes.

Chapter 5 presents the discussion of the results

CHAPTER 5

DISCUSSION AND IMPLICATIONS

5.1 Introduction

In chapter 4 similarities were discovered either in the preferences for, or in the rejection of, certain items on the 17-item data-gathering instrument by the three samples surveyed. On the other hand, significant differences were also found between the responses of the samples to several items. In this chapter, these preferences and choices are interpreted and discussed in terms of the most recent trends in South African science education and government policies. Possible explanations for the significant differences in preferences for or against certain items are suggested.

5.2 Discussion of selected quantitative findings

5.2.1 Variations in the preferences for particular items by different groups

Introducing more gender issues in science (Item 2)

In Table 4.4 on page 57 a significant difference occurred in the responses to item 2 '*introducing more gender issues in science*' ($p = 0.03$). This is because 32% of sample 1 indicated their agreement for this item as against 44.5% of sample 2. In addition, 68% of the respondents in sample 1 disagreed with this item as against 55.5% in sample 2.

A comparison between samples 1 and 3 (Table 4.6 page 60) also indicated a significant response difference for item 2 (chi-square = 27.90, $df = 1$, $p < 0.001$). The Cape Town urban sample showed a greater amount of agreement with the suggestion of a greater emphasis on gender issues in the science education curriculum, compared with their rural

teachers and the Pretoria sample. Nevertheless, all three samples did not think gender issues are a specially important priority in improving the teaching and learning of science and technology (see Table 5.2 on page 77). Their reasons are recorded in section 4.3.1 of the qualitative findings on pages 65-66. McArthur and Wellner (1997:95) support their claims with the following statement: -

“using a gender-inclusive teaching strategy.... instead of allowing for each student to develop the cognitive abilities necessary to understand and do science, may end up supporting the flawed belief that there is a girl’s way and a boy’s way of doing science.”

Concentrating more on South African environmental issues (item 3)

In this study a highly significant difference ($p < 0.001$) occurred between the 134 Setswana-speaking science teachers (sample 1) and the Pretoria science Expo students (sample 2) with regard to their preferences for item 3 in Table 4.5 on page 58. A similar variation occurred between the 134 Setswana-speaking science teachers (sample 1) and the 75 Cape Town science Expo students (sample 3) in Table 4.7 on page 61 in respect to the frequencies of their responses to this item. Both samples of young Expo pupils seem to differ with their older science teachers on the issue of the relative importance of environmental issues in an improved science curriculum for South Africa. Also, when the samples of Expo students from Cape Town and Pretoria are combined, their preference, as a group, for item 3 appears as follows: -

Table 5.1 A comparison of the preferential and non-preferential responses for ‘More environmental issues’ by the 1997 Expo students and Setswana science teachers

	All Expo students (N = 275)		Setswana science teachers (N=134)	
	<u>Best choice</u>	<u>Least choice</u>	<u>Best choice</u>	<u>Least choice</u>
<u>Item3:</u> More environmental issues	32	11	9	14

Combined in this way, the responses of the mainly urban Expo students are even more significantly different from those of the rural Setswana science teachers (chi-square = 6.50; $p = 0.01$; $df = 1$).

Data from 72 rural Tsonga novice teachers' responses to item 3 are reported in Rochford *et al.* (1996:197), with four respondents selecting item 3 as "best choice", but 12 respondents selecting item 3 as a "least choice". Hence, the same pattern occurred with the 205 Tsonga science college students (Rochford *et al.* 1997a: 114) although 50% of these respondents were biologists. In this respect, the response preferences of both Tsonga and Setswana science teachers are similar for item 3.

Samples from the rural areas seem not to be concerned about environmental issues. Reasons for this could only be speculative. Gray (1997:288) also reported that the results of the TIMSS survey revealed that the majority of the South African students seemed to be unaware that science could address environmental problems such as air pollution, destruction of endangered species, damage to the ozone and problem with nuclear power stations.

Learning science through African indigenous technology and culture (item 15)

The rejection of item 15 by all three samples (Table 5.2 on page 77) might be accounted for in terms of the fact that some teachers may not know much about indigenous technology (Spencer, 1997:447 and Baker, 1996:19), and this might therefore explain the high rejection of '*Learning science through African indigenous technology and culture*' by their pupils as well. This was supported by the reasons given by the respondents for rejecting this item (see section 4.3.1 on page 69).

One of the possible reasons given for a negative perception of science in Africa is the mismatch between the curriculum content and the everyday experiences of the African student (Dlamini, *et al.* 1996:222 and Knamiller *et al.* 1995:74). Secondly, there is the

usual conflict between the established scientific pedagogy of enquiry and the social and cultural values of African societies (Ogunniyi, 1995:95).

Spencer further explained that her research findings revealed that indigenous technology has a positive effect on pupils' learning and had the potential to improve attitude towards science. A decade ago Amara (1987:317) also supported the use of indigenous technology as it was giving the pupils studying science, mathematics and technology the opportunity to carry out scientific processes of observation, data collection, computing and making generalisations.

Perhaps South Africa needs to explore this teaching strategy as Spencer (1997:542) states that: -

“If our schools are to impact basic, relevant and usable knowledge, indigenous technology cannot be ignored. The starting points for learning are on real everyday activities or problems which have science and technology components, instead of starting with abstract concepts and processes.”

Writing for Australian science, technology and culture curriculum, Fler (1997:17) asked if there is recognition of traditionally orientated Aboriginal children's sophisticated knowledge of materials and design. She further made the following suggestion: -

“Our curriculum should bring together the range of world views. However, to do this effectively and respectfully, we need to know more about the different types of knowledge construction in science and technology. Unless we do, we cannot begin to understand the range of views expressed by children – as situated within the context of their culture. Given our multicultural society we need to move beyond a one-world view to a multiple worldview. We have a responsibility not only to acknowledge children's understandings in both science and technology, but also to respect and value their views. In doing this we need to broaden our understanding of what science and technology may mean, how they look in practice, and how we should construct educational experiences for our children. These are our future challenges.”

Baker (1996:19) gave examples of indigenous knowledge, which he identified as unknown by most non-indigenous people in Australia (*quoted from Brindon, 1988*).

These are: -

- Highly developed pharmacology;

- The de-toxification of cycads for food;
- The knowledge of vegetation management by fire to maximise food; and
- Extremely detailed and accurate genealogical information.

In future, if indigenous technology is included in the science and technology curriculum as a means of trying to improve their teaching and learning, we might therefore investigate the indigenous technology contained in a South African context. Kawagley *et al.* (1998:143) substantiated this suggestion by stating:

“Pedagogy that draws from indigenous knowledge, worldview, and culture can provide students with not only locally relevant science education, but also in many ways with the kind of learning environment and experiences recommended for students everywhere.”

5.2.2 Congruence in the selection of the best policy choices among the three samples

There are very high correlations ($r = 0.81$, $r = 0.91$ and $r = 0.83$) between samples on their choice of the best policy in the 15 items presented to them. This means that there is a high degree of consistency (Table 5.2, page 77) in the samples' choices of the best policy and the least important policy for improving the teaching and learning of science and technology.

Introduction of more real life skills in science (item 1)

There is a high degree of consensus in the best policy preferences among the three samples (Table 5.2, page 77). All three samples regard the “*introduction of more real life skills in science*” as the best option for improving the science curriculum. The recommendation agrees with the results obtained by Wilkinson and Ward (1997:51) on the aims for laboratory work in which students and teachers rated “*To make science more interesting and enjoyable through actual real life experience*” as the highest priority. Watts *et al.* (1997:350) also agreed that an emphasis on real life problem solving through active classroom tasks is stimulating and motivating for learners.

On the other hand, Watts *et al.* warn against the difficulties of using real life situations in teaching science because, in their opinion, it is not always clear to the teachers how easily this sort of work fits into the curriculum. They highlighted that teachers commonly fail to approach applied social issues in science and may therefore be reluctant to attempt new teaching strategies where the outcomes are uncertain for them.

Mayoh and Knutton (1997:865) also established that incorporating out-of-school experience in science lessons can clearly be a powerful tool in the hands of skilled teachers and can make a strong contribution to successful learning and to bringing the everyday and scientific domains. They also cautioned that teachers need to recognise that the mere mention of everyday events may not necessarily be as effective as they assume in improving school science learning.

Ratcliffe (1998:59) warned that,

“Unless we are prepared to assist pupils in understanding the complexity and evidence in forming opinions, they may fail to realise the relationship of ‘school science’ to real life problems.”

Introducing more self-discovery in science (item 8)

Table 4.4 on page 57, Table 4.6 on page 60 and Table 4.8 on page 63 indicate a significant difference on the agreement of item 8 '*making more use of self-discovery and self-teaching*'. However, Table 5.2 on page 77 indicates that there is a high level of consensus among the three samples on '*making more use of self-discovery and self-teaching*' as one of the best ways to improve the teaching and learning of science and technology. The statistical difference may therefore be attributed to the size of samples.

Using more self-discovery and self-teaching in science and technology teaching and learning could benefit South Africa in years to come. Solomon (1998:292) advocates this with the following statements: -

Table 5.2: Ordinal rank congruence in the policy preferences of samples of 409 science/technology teachers and students in 1997.

Suggestions for improvement	Rankings of importance		
	Setswana-speaking	Pretoria science	Cape Town science
	Science teachers	Expo students	Expo students
	(sample 1) N = 134	(sample 2) N = 200	(sample 3) N = 75
1. More real life skills in science	1	1	1
2. More gender issues in science	15	15	14
3. More environmental issues	9	7.5	5
4. Science for community development	7	7.5	8
5. More attention to language	14	12	14
6. More focus on the disadvantaged	11.5	11	10
7. More competitions in science	4	3	6.5
8. More self-discovery in science	2	2	3.5
9. Core plus options curriculum	5	9	6.5
10. More primary school S-E-T	3	4	3.5
11. Wider community consultations	10	13	12
12. Computer-aided science	5	6	2
13. Promoting careers in science	7	10	9
14. Excitement and adventure	11.5	4	11
15. African indigenous science	13	14	14

Spearman correlation between samples 1 & 2, $r = 0.81$

Spearman correlation between samples 1 & 3, $r = 0.91$

Spearman correlation between samples 2 & 3, $r = 0.83$

- We should teach our young people independent ways of learning in science so that they can go on learning about science for interest; and
- We should teach them learning skills so that they can be retrained for new work in science when this becomes necessary.

The above statements coincide with South Africa's policies on science and technology education. The White Paper (RSA, 1995:30) suggested a programme for '*student recovery*' in science, technology and mathematics. Such interventions would be part of a comprehensive programme of special measures, which are needed to enable many more students 'a second chance' to follow science-based careers. In response to this, the White paper (Department of Arts, Culture, Science and Technology, 1996:73) mentioned that it is necessary to establish a structured national campaign for continued education, training and enrichment of the group of mathematics and science educators; and retraining educators qualified to teach other subjects to become mathematics, technology and science educators.

The reasons given by the respondents for choosing item 8 as one of the best teaching and learning strategies for improving school science and technology are mentioned in section 4.3 on page 54 of this dissertation. Most of them agree with the following reasons given by Goodwin and Adkin (1997:53) for using a problem-solving approach as a means of enhancing the teaching and learning: -

- Students develop critical thinking skills.
- They become actively involved in the learning process.
- They experience excitement about studying science, as rigorous problem solving can be enjoyable.
- They increase self-esteem by knowing that their own individual effort contributes positively to the team solution of the problem.
- They develop problem-solving skills that can be applied to other areas in their lives and other academic disciplines.

- They learn how to design an experiment and carry out research, including observations and data handling.
- They learn how to organise and interpret scientific information.
- They experience the interrelationship of science with the world around them and with other disciplines such as literature, art and social studies.

Lee (1997:114) stated that a new key emphasis in recent science education reform involves inquiry or 'doing science'. To make sense of the world around them, students engage in scientific enquiry by formulating questions, proposing hypotheses, manipulating materials, describing objects and events, experimenting with variables, gathering data, verifying evidence, making inferences, constructing explanations and drawing conclusions.

5.3 Discussion of qualitative findings

Several suggestions emerged from the qualitative data. These were summarised in section 4.3.2 on pages 69-70, the main recommendations being centred on more *resources, science campaigns, learner support services and teacher support services.*

Resources

DACST (1996:75) recommended developing and improving the infrastructure in schools for more effective participation in mathematics and science programmes. The DACST White Paper pointed out that the education budget makes up about 22% of the total national budget and is not likely to increase in the next few years. It further suggested that the best solution to utilise the limited funds available is a better deployment of the education resources to achieve national goals by making it easier to share educational material and teaching expertise.

In spite of the above 1996 policy recommendations, a 1997 survey by Gray (1997:115), found that many schools had inadequate buildings, poor or non-existent libraries, laboratories and other facilities, overcrowded classrooms and textbook shortages. His

findings agree with the recommendations in this study, in which both the teachers and students suggested a priority need for resources in the form of libraries, library books, laboratories, science equipment, more textbooks and computers.

Science campaigns

One of the recommendations that emerged from the qualitative studies is that of having science campaigns, and this agrees with the government recent policy for popularising science and technology. The Republic of South Africa, through the Department of Arts, Culture, Science and Technology (DACST) has officially declared 1998 as "*The Year of Science and Technology*". This is South Africa's first nation-wide initiative to promote science and technology. The key message of this project is that *science and technology are interesting*. A total of R4.5 million has been allocated by the DACST to the provinces for this project (FRD News, 1997:1).

Learner support services

The students who participated in this study recommended extra-curricular activities that will encourage them to do additional practical work.

In their study of "Factors affecting student choice of career in science and engineering", Woolnough *et al.* (1997: 120) made the following recommendation: -

" One of the most influential factors, and certainly one that is very cost effective, is the provision of extra-curricular activities in science which stimulate imagination, motivation and creativity of students. In particular the involvement of students with their own research projects, whether as part of their school curriculum or as out of school projects, has proved to be of permanent value. These projects can be developed through science clubs or national or local competitions, through school-industry links or a national award scheme. Government and industry can give encouragement and resources for such projects- I suspect that such ventures could, and in places already are, a highly cost-effective way of getting young people 'switched on' to science through doing it."

In another study, Woolnough (1997: 71) offered the following suggestions to encourage more students to enjoy and follow science: -

- Priority must be given to the recruitment, training, support and deployment of science teachers to teach enthusiastically within their expertise.
- A curriculum that is relevant, accessible and stimulating should be developed.
- Practical work should be pruned and redirected so that students gain personal experience of genuine problem-solving projects.
- The development of extra-curricular activities in science, with science clubs, science competitions, individual and group projects and stimulus activities that fire the students' imaginations.

Teacher support services

In their recommendations, the sample of Setswana teachers expressed a need for more frequent in-service training in the form of workshops and field trips. Further study could be done to investigate what their in-service needs are, in the light of their choice of *'introduction of more real life skills in science'* and *'making more use of more self-discovery and self-teaching'*, as their best recommendations for the improvement of science and technology teaching and learning.

The White Paper (RSA, 1995:61) cited the following from the RDP White paper: -

“Human resource development, education and training are key inputs into policies aimed at higher employment, the introduction of more advanced technologies, and reduced inequalities.”

In spite of the above policy statement teachers in the North West Province felt that the teacher support service is not enough. In the light of the findings by The Education Foundations reported in section 2.1.1 on page 12 of this dissertation, and the envisaged *'curriculum 2005'*, science and technology teachers need more teacher support.

In assessing the rural and non-rural secondary science teachers' in-service needs in the United States of America, Baird *et al.* (1994:555) found the following among their greatest needs: -

1. To motivate students to want to learn science;
2. To discover sources of free and inexpensive science material;

3. To learn more about how to use computers to deliver and manage instructions;
4. To find and use materials about science careers; and
5. To improve problem-solving skills among their students.

Recommendations from the South African students included more learner support programmes, like field trips and excursions. In order for teachers to be able to provide the kind of support needed by their pupils, the provision of such in-service programmes must be a priority in the quest for improved science and technology teaching in South African schools.

5.4 A response from seven combined groups on the 17-item instrument

Table 5.3 on page 83 links the 1996-1997 best/least policy responses obtained from sample 1 (Table 4.1 page 50), sample 2 (Table 4.2, page 52), and sample 3 (Table 4.3, page 54) with the corresponding responses obtained from four additional samples as reported in Rochford *et al.* (1997a: 114 attached in Appendix A). Using the combined data, it is clearly evident that, across the samples, the items that record a substantial and consistently high priority, as *best* policy recommendations for the improvement of school science and technology, are items 1 and 8, followed by item 10 and item 12.

As the above recommendations are embedded in, and directly relevant to South Africa's new 'Outcomes Based Education', which combines the acquisition of both skills and knowledge (Department of Education, 1997:13) it is highly likely that by the year 2005, these recommendations will still be a curriculum priority for the improvement of teaching and learning of school science and technology.

Table 5.3: The best/least policy preferences of seven diverse samples forming a total combined group of 1035 science/technology lecturers, teachers and students in South Africa in 1996 and 1997.

Suggestions for improvement	Frequency of occurrences (N = 1035)	
	Best Recommendation	Least Important Recommendation
1. More real life skills in science *	311	22
2. More gender issues in science •	43	324
3. More environmental issues	109	80
4. Science for community development	95	70
5. More attention to language •	38	338
6. More focus on the disadvantaged	56	109
7. More competitions in science	143	104
8. More self-discovery in science *	250	58
9. Core plus options curriculum	132	89
10. More primary school S-E-T *	217	66
11. Wider community consultations	42	83
12. More computer-aided science	181	53
13. Promoting careers in science	113	60
14. Excitement and adventure	86	58
15. African indigenous science •	60	290

* Best policy preferences

• Least favoured policy preferences

5.5 General comment on undiscussed items

In support of one of the findings of Rochford *et al.* (1997b), it has also emerged from the present study that similarities occurred consistently among samples on the choice options of item 12 '*Introduction of computer aided instruction*' and item 10 '*Introduction of more primary S-E-T*' among the better favoured policy recommendations; and the high rejection of item 5 '*Paying more attention to language issues in science*' as the least important recommendation among the 15-items for improving the teaching and learning of science and technology. However, it is not feasible to discuss in detail all the findings for every one of the fifteen items for all the samples individually, in a short research dissertation of this nature.

5.6 Other related research findings

Rochford *et al.* (1996) conducted a survey using four diverse samples of respondents. '*Introducing more real life skills into science, such as technical, trade, industrial, commercial, manufacturing, marketing and technological skills,*' was ranked as the first priority by three samples and as the second preference by the fourth sample. All four samples, comprising a total of 302 respondents, adjudged three policy recommendations to be of least importance. Three related to the issues of attention to *gender, language, and learning through African indigenous technology.*

Using 809 respondents, including lecturers in engineering and science, teachers of science and technology, and students in a diversity of lecture groups or classes of science and technology, Rochford *et al.* (1997b) found that one of the policies favoured by many young students for improving mathematics/science/technology education is the increased "*use of computer-aided instruction and computer interfacing.*" However, the samples of lecturers and teachers tended to rank this recommendation as a lesser priority, preferring alternative pedagogic strategies instead. Young respondents tended to favour the increased use of computers more than the older respondents.

Rochford and Lose (1998, in press) conducted a study using samples of 44 Xhosa science teachers and 47 Xhosa science/technology students in year or grade 11 at historically disadvantaged Cape Town High schools in underdeveloped communities. The results that emerged from the open-ended section of the survey revealed that the 47 Xhosa students strongly recommended “*more learner support in science lessons*” and “*more applied science excursions.*” These needs were expressed in addition to their preferences for “*more computer-aided instruction in science*” and “*more basic science and technology in primary schools.*” The sample of 44 Xhosa science teachers strongly recommended “*introducing more real life skills into science*” and “*making more use of self-discovery and self-teaching*” in the learning of science/technology. “Paying more attention to gender issues” and “introducing a compulsory core plus freely chosen science/technology options” were all rejected by both samples.

5.7 Discussion of the research method

A survey is an appropriate research method for gathering data in this kind of research, but there were shortcomings in the survey of the Pretoria science Expo students and the Cape Town science Expo students. About 25% of the Pretoria science Expo students and 40% of the Cape Town science Expo students did not complete the open-ended section of the questionnaire which required them to give reasons for their choices of *two best* policies and *two least important* recommendations; nor did they make additional recommendations for the improvement of school science and technology. Students in both groups cited time-constraints, while setting up or making adjustments to their science projects on display. Students who completed the entire questionnaire took an average of 10 minutes. This factor alone left the researcher to conclude that the length of the questionnaire was not the cause but the open-ended section might have been the discriminating factor.

However, had the young respondents been allowed to take home the questionnaires, some may not have returned their responses. For students, it was felt best to use data from a willingly responsive, captive, intact sample in the available time, since all respondents

were able to complete the essential first section, i.e. the 17 items, efficiently and in a helpful and interested manner, in good spirit.

The problem of non-completion of the open-ended section was not experienced with the Setswana teachers who were surveyed with postal questionnaires. Waiting time for postal survey and reminders to increase the number of responses were considered as constraints, but a 70% response return when surveying professional populations is considered adequate in mail-survey research (Wiersma, 1991:181).

5.8 Discussion of weakness or limitations of the survey research instrument itself

Due to the high rejection of item 2, item 5 and item 15, it is recommended that *'Paying more attention to gender issues in science'*; *'Paying more attention to language issues in science'*; and *'learning science through African indigenous technology'* should be excluded in the future use of this instrument in general surveys.

Reduced support occurred for item 6 *'Having the disadvantaged of South African majority as its focal point'* and for item 11 *'All interested groups in the communities should be consulted'* as best policy recommendations. It is therefore suggested that these items should be excluded in the future use of this instrument in general surveys.

The open-ended section of the questionnaire might be left out especially if the survey instrument is to be administered to school pupils. The use of [B] for *"disagree"* proved to be confusing to a few number of young respondents. It is therefore suggested that [D] might be used.

Incorporating the qualitative suggestions found in 1997, the new modified instrument for use in 1998/99 with two new items might be as follows: -

Table 5.2 English version of the Sokopo (1998) instrument for

IMPROVING SCIENCE/TECHNOLOGY TEACHING IN SOUTH AFRICAN SCHOOLS

As part of the Reconstruction and Development Programme, I think that the learning and teaching of school Science/Technology can be improved in South African schools or colleges by: -

Please circle agree [A] or disagree [D] for each item.

	CIRCLE	
	<u>AGREE</u>	<u>DISAGREE</u>
1. INTRODUCING MORE REAL LIFE SKILLS INTO SCIENCE (e.g. technical, trade, industrial, commercial, farming, mining, manufacturing, marketing and technological skills).	[A]	[D]
2. CONCENTRATING MORE ON SOUTH AFRICAN ENVIRONMENTAL ISSUES (e.g. problems of soil loss and possible solutions, health care, sanitation, air pollution, electrical supply, conservation of plant and animal species).	[A]	[D]
3. USING THE SCIENCES TO ADVANCE AND DEVELOP THE SOUTH AFRICAN COMMUNITY SOCIALLY AND ECONOMICALLY (e.g. to help solve political, labour, citizenship, social and ethical problems in South Africa).	[A]	[D]
4. ENCOURAGING COMPETITIONS , with more enterprises to be organised between schools and within schools in South Africa (e.g. students participating in Expo, science fairs, science Olympiad, science essay writing competitions etc.).	[A]	[D]
5. MAKING MORE USE OF SELF-DISCOVERY AND SELF-TEACHING (i.e. students designing their own experiments and fieldwork studies and developing skills for problem solving, creative thinking etc.).	[A]	[D]
6. CHANGING CURRICULA TO A COMPULSORY BASIC SYLLABUS PLUS OPTIONS (i.e. students do some compulsory science modules but choose others freely and individually for their own personal relevance and interest).	[A]	[D]
7. GIVING ALL PUPILS IN THE PRIMARY SCHOOLS IN SOUTH AFRICA MUCH MORE BASIC SCIENCE AND TECHNOLOGY than they receive at present.	[A]	[D]
8. USING COMPUTER-AIDED INSTRUCTION AND COMPUTER INTERFACING AS PART OF SCIENCE EXPERIMENTS (e.g. to collect, display, analyse and plot data; and to explain science concepts).	[A]	[D]
9. PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY AMONG SCHOOL PUPILS IN SOUTH AFRICA.	[A]	[D]

10. **SHARING AND INCREASING THE INTELLECTUAL EXCITEMENT AND SENSE OF ADVENTURE, WHICH THE SCIENCE OFFERS**
(its benefits, optimism, encouragement, spirit and challenge to the South African pupils). [A] [D]
11. **USING MORE EXTRA-MURAL ACTIVITIES IN SCIENCE AND TECHNOLOGY**
(e.g. field trips; excursions; visit to universities, science centres, colleges and technikons to do additional practical work; doing projects; forming science clubs, etc.) [A] [D]
12. **PROVIDING MORE RESOURCE SUPPORT MATERIALS**
(such as more science textbooks, science equipment, science library books, science homework sheets and science campaigns). [A] [D]
- (a) THE **TWO BEST** WAYS OF IMPROVING SCHOOL SCIENCE/TECHNOLOGY IN SOUTH AFRICA MENTIONED ABOVE ARE NUMBERS () AND ().
- (b) THE **TWO LEAST IMPORTANT** RECOMMENDATIONS MENTIONED ABOVE ARE NUMBERS () AND ().

5.9 Chapter summary

In this chapter, the results of several small-scale surveys in relation to the most recent trends in South African education policies in school science and technology, and in relation to the recent research findings from other countries on these issues, were discussed. A Spearman rank order correlation coefficient was also used to establish the high correlation between the ordinal ranked preferences of the three samples of respondents. Results from four 1996 samples were linked with the results from the three samples surveyed in this study to establish the best and least important policy recommendations from the enlarged grouping of 1035 respondents. Findings from previous studies were discussed and explained. Implications and suggestions were also made for a refined data gathering instrument for future use in subsequent studies.

Chapter 6 will address recommendations for further research and a conclusion will be made.

CHAPTER 6

RECOMMENDATIONS AND CONCLUSION

6.1 Recommendation on the research method

Because non-probability survey sampling was used in this study, the results are therefore not generalisable beyond the three samples. This is a weakness in the research method, although it was partly off-set by showing that most of the findings were in harmony with those obtained from several earlier samples in 1996 and 1997.

Recommendation 1

For future studies, it is recommended that probability sampling methods be used for larger studies to produce results that are more generalisable and which may replicate current findings with more precision or consistency.

6.2 Recommendations with regard to science and technology teaching and learning

Based on the findings of this study, it is recommended that:

Recommendation 2

More real life skills be introduced into school science and technology lessons, especially scientific skills related to agriculture, medicine, commercial, mining, technical, trade, marketing, manufacturing, industrial and technological skills.

Recommendation 3

There should be more use of self-discovery and self-teaching in school science and technology, for example, in the form of pupil practical work, excursions, field work, science clubs, projects, etc.

Recommendation 4

The use of computer-aided-instruction in science and technology might be beneficial, and pupils' preferences in this regard should be sought through consultations or surveys.

6.3 Recommendations with regard to teacher pre-service and in-service

Because the successful implementation of recommendations 2 and 3 depends on the quality and skills possessed by South African teachers, it is therefore recommended that:

Recommendation 5

The pre-service and in-service training of teachers could be designed to include more use of real life skills in science and technology.

Recommendation 6

The pre-service and in-service training of teachers could be designed to include more use of self-discovery and self-teaching in science and technology.

Recommendation 7

The use of computer-aided-instruction for science and technology could be a greater and more comprehensive part of teacher pre-service and in-service programmes.

6.4 Recommendations with regard to science education policy

Recommendation 8

Considerations could be given to introducing more science, engineering and technology concepts in the primary schools than at present.

Recommendation 9

The South African government, industries and Independent Development Corporations might help by allocating more funds for science campaigns, the building of libraries and laboratories, and assist schools with relevant equipment.

6.5 Recommendations for future research

Recommendation 10

For further research, another new instrument might be developed with one main item on 'the introduction of more real life skills in science' and a second main item on 'using more self-discovery and self-teaching in science' as the two core items. Related sub-categories might be developed, in order to established which particular real life skills and self-discovery skills are relevant to the teaching and learning of science and technology in South African schools in (a) general science classrooms; and (b) specific contexts (e.g. 'science for economics students'; 'science for history students'; etc).

Recommendation 11

The original 17-item instrument proved to be a convenient instrument which produced generally consistent results across different categories of people, i.e. science university lecturers, science teachers (Xhosa and Tswana), science students (English, Xhosa and Afrikaans, science Expo students and Tsonga science college students. It is suggested that similar surveys might be considered in other countries with a first world/third-world interface which are trying to improve the teaching and learning of science and technology to see whether similar results are obtained in emerging nations.

Recommendation 12

To date the old (1996-1997) 17-item instrument is available in English, Afrikaans and Xhosa. It is suggested that the new 1998 recommended 14-item instrument might also be translated into the other South African official languages if surveys are to be conducted at junior high school levels.

6.6 Conclusion

In this study and in other similar surveys in 1996-1998, *introducing more real life skills in science; using more self-discovery and self-teaching in science; introducing more science-engineering-technology (S-E-T) programmes in primary schools and using more computer-aided instruction in science* emerged as the four best policy recommendations for improving the teaching and learning of science and technology from a variety of samples across South Africa. A need for more *science campaigns, teacher support, learner support, building of laboratories and libraries* are the main recommendations that emerged from this study. The findings provide preliminary support for the 1995 White Paper's criteria for preparing and recruiting students for subjects in short supply, particularly science and technology, and for improving current school science curricula. However, the Cape Times (14 August 1997) reported the following warning by the Human Sciences Research Council: -

“When trying to improve mathematics and science education in South Africa there will be no single magical cure-all solution.”

Woolnough (1997:70) suggested that there is a need to focus more on motivational factors in science teaching, taking into cognisance that no one single approach will motivate all students.

Looking to the future with encouragement and optimism, it is heartening to be guided by the skills and the ideals of Kyle (1997b: 770) who made the following recommendation: -

“ Our young people are presently entering a world where reasoning, problem solving, and lifelong learning skills are required. Those denied access to those skills will not only become a burden to themselves and the society, they will also be disenfranchised from the world of the third millennium.”

Now more clearly focussed, South African science curriculum policies enable dedicated science teachers to stand and look forward to the year 2000 with better direction and hope.

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APPENDIX 1

A copy of a published research article
which forms part of this dissertation

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Improving the Teaching of Science and Technology in the New South Africa: Concurrence Between the Policy Preferences of Lecturers, Teachers and Students*

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A review of the science–engineering–technology (S-E-T) literature in 1995 yielded fifteen possible policy recommendations for the improvement of teaching methods, curriculum and textbooks in current programmes of science-engineering-technology. These possible relevant alternatives were extracted from the current literature by a panel of seven South African researchers in response to the reasons given by 107 Xhosa-speaking science students for being underprepared for tertiary studies in engineering and technology in 1995. Subsequently, five diverse samples of S-E-T lecturers, teachers and students, comprising a total of 740 respondents, were surveyed across the Republic of South Africa in 1996 and 1997 as part of S-E-T policy development for the new Reconstruction and Development Programme. Substantial measures of agreement were found to exist among the samples' policy preferences. The respondents consistently highly prioritised making improvements by *introducing more real life skills into science, such as technical, trade, industrial, commercial, manufacturing, marketing and technology skills*; and by *more self-discovery in science*; but several significant differences were also found between the policy preferences of rural and urban teachers and lecturers in S-E-T.

INTRODUCTION

The 1995 UNESCO International congress of Engineering Deans and Industry Leaders had, as its primary aim, dialogue on the adaptation of engineering education and research to the needs of national and international economies and cultures. Particular emphasis was placed on developing countries evolving towards a market economy [1].

Its summary recommendations advocated, among other things, that engineering education should utilise computer-aided instruction and problem-based learning, including industry perspectives; and that the engineering curriculum should broaden to include environmental concerns and business issues [2].

At the same time, the Human Sciences Research Council in the Republic of South Africa was also emphasising investigations which would contribute to-

wards the realisation of the goals of the Reconstruction and Development Programme of the new government [3]. These initiatives flowed from the *White Paper on Education and Training in a Democratic South Africa: First Steps to Develop a New System*, which the Government of National Unity released on 15 March 1995 [4].

In its statements of *Values and Principles of Education and Training Policy* the White Paper stated that an appropriate mathematics, science and technology initiative is essential to make up the chronic national deficit for economic advancement.

It also stated that environmental education, involving an integrated, interdisciplinary and active approach to learning, must be a vital element of all levels and programmes of the education and training system.

In its statement of *Values and Principles of Education and Training Policy* the White Paper advocates:

18. *Curriculum choice, especially in the post-*

* An expanded and revised version of a paper presented at the Congress

compulsory period, must be diversified in order to prepare increasing numbers of young people and adults with the education and skills required by the economy and for further learning and career development.

19. An appropriate mathematics, science and technology education initiative *is essential to stem the waste of talent, and make up the chronic national deficit, in these fields of learning, which are crucial to human understanding and to economic advancement.*

20. Environmental education, *involving an interdisciplinary, integrated and active approach to learning, must be a vital element of all levels and programmes of the education and training system, in order to create environmentally literate and active citizens and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources* [4].

It is in this context, and against the above background, that the findings reported in this paper are presented.

PURPOSE

The objectives of this investigation were to uncover some of the most important reasons why at least some African science students tend to avoid continuing in their chosen area of concentration by declining to register for engineering, science and technology based subjects at tertiary level; and to determine which of fifteen possible policy recommendations for the improvement of current programmes of science-engineering-technology (S-E-T) would be most highly prioritised and agreed upon by five diverse samples of South African lecturers, teachers and students in S-E-T.

BACKGROUND

A recent study of practical work in science teaching in developing communities has pointed out that these communities fail to produce sufficient numbers of graduates in technology and in science-related professions, suggesting that this is caused by the dominance of lecturing as a teaching method, and by the lack of a practical approach in science teaching [5]. Other reasons previously cited for African students' reduced interest in science were the dull and uninteresting way in which the subject was presented; but the underachievement of science students in Nigeria, including the dropping of science after matriculation,

was attributed not to a single cause, but to a combination of factors which were thought to be somehow associated [6]. A study in Qwaqwa at about the same time revealed that final year high school pupils considered science a difficult subject, but the main problem was considered to be poor teachers, who then blamed the lack of apparatus and facilities [7].

It has been recently reported in Australia that Aboriginal and Torres Strait Islander students also recorded low enrolments in the physical sciences and mathematics; and that nationally males have been predominant in the physical sciences and technical studies, while females have appeared in proportionately greater numbers in languages other than English (LOTE), home economics and biological and other sciences [8].

In a recent South African survey of first year university engineering students at the University of Stellenbosch, most respondents said they chose to study engineering when they were about 13–14 years old, and then decided on which speciality to focus when they were in their final year of high school [9].

Not all students with an interest in, and an aptitude for, tertiary level studies in engineering, science and technology however continue their inclination towards this area of academic concentration. In the United States of America, for example, poor science teaching, lack of nurturing, science being considered too difficult and time consuming, and particularly negative experiences in science courses have been cited as important reasons for a 40% nationwide attrition rate among science majors [10].

Similar reasons for avoiding or underachieving in science or technological subjects have been suggested by students in South Africa, so the present empirical study was initiated in order to obtain more systematic and cohesive data on this problem. The study was deemed to be particularly important because it has recently been determined that whereas Japan boasts 71 scientists and engineers for every 1000 people, in South Africa the figure is only 3.3 and falling [11].

It is against this background that two sequential studies were conducted.

STUDY NO. 1

Sample and procedure

In September 1995 a total of 127 science students in their final year of study at three Xhosa/English-speaking high schools in Cape Town completed the one-page questionnaire reproduced in Appendix 1. The survey was administered during school hours by

Nomhle Mandla, who is fully Xhosa/English bilingual, and who conceived this section of the study [12]. First, the procedure was briefly explained to the three classes of students, and then it took approximately seven minutes to complete the data collection. Of the 127 questionnaires administered, 20 were subsequently discarded because they had been filled in incorrectly. Of the remaining 107 questionnaires, 65 were completed by females and 42 by males.

The instrument development

The final version of the instrument presented in Appendix 1 was the outcome of two exploratory pilot studies. In the first developmental phase, 15 Xhosa/English-speaking students were given only an open-ended survey form. This sought to elicit any number of reasons why African students were demotivated from persisting with studies in engineering, science and technology at tertiary level. The outcome of this pilot trial was that some students were found to be lacking an English vocabulary with which to express their reasons. A list of helpful key words was consequently appended as a footnote-guide in the second version of the questionnaire, even for those students who chose to respond in their home language, Xhosa.

The following instruction was added to the questionnaire in the second pilot study:

At the bottom of this page are some words you might like to mention:

Parents, money, friends religion, somebody respectful, science teacher, language, culture, profession, industry, creative, inventive, environment, technology, interest, excitement, curiosity, boring, difficult, time-consuming, concentration, practical work, libraries, understanding, tastes and smells, qualifications, career, high marks. Please use other words in any language.

A total of thirteen different reasons subsequently emerged in the second pilot trial for the demotivation of at least some African science students from pursuing their chosen interest in science and technology at the tertiary level. Three of these reasons drew very little corroborative response or support from the African students' peers, so the final instrument (Appendix 1) comprised ten items. The omitted minority reasons were, *I hate the taste and smell of chemicals; I am not well motivated; Science is too theoretical; There are no exhibitions; and there is no career guidance.*

The wording of this scale was critiqued and refined by a group of eleven bilingual or trilingual sci-

ence/technology teachers until consensus had been reached on the format and vocabulary of each item.

Findings

Of the 107 high school science graduates, 28 indicated their intention to discontinue scientific studies at the tertiary level, but 79 said that they intended to persist with science/engineering/technology at a university, college or technikon despite being concerned about their previous record of underachievement or under-preparation in science at high school level. The 79 science persisters comprised 45 females and 34 males; the 28 science non-persisters comprised 20 females and eight males. In this respect there was no significant difference between the gender distribution across persistence ($\chi^2 = 1.25$; $df = 1$; $p = 0.30$).

Table 1 presents the rankings and most important reasons offered by the Xhosa science students for their inclinations to avoid registering for science subjects at tertiary level.

Discussion

The results obtained from the three African schools disclosed no significant difference between male and female science students' reasons for being inclined to terminate their study of science at the end of their high school years. Male and female Xhosa science students equally cited *lack of teacher explanations, lack of science laboratory practicals and personal lack of scientific background knowledge* as the three main reasons discouraging them from pursuing a scientific career at tertiary level.

These empirical results are consistent with the qualitative reports given in earlier studies [5-7][10]. They also support the recent government decision to allocate an amount of R2.7 million (\$800 000) specifically for the increased training of science teachers for impoverished or historically disadvantaged, understaffed high schools in South Africa [11].

STUDY NO. 2

As a sequel to the findings of the first study, a survey of the local and international science-engineering-technology education literature [13-46], by a team of seven postgraduate research students and staff at the University of Cape town in 1995, disclosed sixteen categories of recurring recommendations for improving current curricula, teaching methods and textbooks in programmes of science-engineering-technology (S-E-T); recommendations which have remained substantiated [47-56].

Table 1: Xhosa science pupils' rankings of their reasons for hesitating to study science and engineering further at tertiary level (n = 107).

Item no.	Reasons for attrition	Mean Score	Rank
1.	Lack of school practical work.	434.04	2
2.	Unclear science explanations.	312.24	1
3.	Tertiary science is too costly.	615.99	7
4.	My underachievement in science.	593.03	6
5.	Science is too difficult for me.	629.36	8
6.	Science practicals are boring.	798.76	9
7.	High science marks are needed.	568.97	4
8.	Science is time-consuming.	580.83	5
9.	My science background is lacking.	517.25	3
10.	Science language is difficult for me.	834.34	10

Instrument development and objectives

Developmental pilot studies of potential instruments occurred using critical research groups of postgraduate science and technology teachers in small-scale trials. Fifteen categories of policy recommendations were carefully worded and selected as being immediately relevant to South African S-E-T education, and to the principles and values stated in the Government White Paper. In summary form these recommendations were as follows:

1. Introducing more real life skills into science/technology [13-18].
2. Paying more attention to gender issues in S-E-T [13][20][21].
3. Concentrating more on South African environmental issues [15][19][22-25].
4. Using the sciences to advance and develop the community socially and economically [13][16][19-21][26-29].
5. Paying more attention to language issues in S-E-T [13][20][21][30-32].
6. Having the disadvantaged South African majority as its focal point [13][20][26][27][33].
7. Encouraging more competitions [26].
8. Making more use of self-discovery and self-teaching [15][19][21][33-36].
9. Changing the curriculum to a compulsory core plus options [13][20][21][29][37][38].
10. Giving pupils in primary schools more basic science and technology [26][29][39].
11. Consulting all interested groups in the community [13][20][29][36][40].
12. Using computer-aided instruction as part of science [41][42].
13. Promoting S-E-T careers among school pupils [16][21][27][29].
14. Sharing science's intellectual excitement and sense of adventure [19][43].
15. Learning science through African indigenous technology and culture [18][44-46].

As a sequel to the preliminary investigation by Nomhle Mandla, these statements of recommendations were then amplified and used to finalise the content of a seventeen item survey instrument (Appendix 2) in order to gather data for science-technology-society policy formation and prioritisation as part of the new Government of National Unity's Reconstruction and Development Programme.

The first items required respondents to say whether they *agreed* or *disagreed* with each of the fifteen suggestions offered for improving school science/mathematics/technology programmes. The final two items requested the respondents to focus on, and select, the TWO BEST ways for improving school science/mathematics/technology in the new South Africa; and to identify the TWO LEAST IMPORTANT recommendations of the fifteen.

The reliability of the responses to the instrument was measured using an intact sample of volunteer science/technology teachers over a period of seven weeks. Test/re-test responses yielded reliability coefficients of $r=0.97$, $r=0.88$ and $r=0.90$ (N = 14).

Samples

The instrument was administered to five convenient samples, from north to south of the Republic and comprising a total of 740 respondents, during the period of May 1996 to May 1997.

Sample 1 consisted of 49 urban BE/BSc graduates specifically committed to engineering, technology or science education as a career. Sample 2 comprised 58 aspirant young scientists/technologists/inventors who entered the University of Cape Town's annual 1996 science talent competition EXPO week. Sample 3 consisted of 205 teachers-in-training specialising in high school science at Giyani College of Education, in the Northern Province of South Africa, 80% of whom speak Xitsonga as their home language. Sample 4 comprised 314 science students in year 8 and 9 in a well established bilingual high school, with a strong science tradition, in the rural Cape. Sample 5 consisted of 114 rural high school science teachers from the North West Province of South Africa, of whom 96% speak Setswana as their home language.

Data collection

Data were collected from the students at a convenient time during normally scheduled science lessons or lectures or practicals. Translated versions of the instruments were available in English, Afrikaans and Xhosa, and students were free to respond in the language of their choice.

Data were also collected from experienced S-E-T teachers and lecturers during four invited seminar presentations at three universities and at one technikon; and from the science teachers in the North West by the normal correspondence system used by the education circuit managers.

Hypothesis

It was hypothesised that strong agreement would occur on at least some of the fifteen recommendations among diverse interest groups in the field of science-engineering-technology education, but that appreciable differences would occur between groups of respondents on their choices of the most or least important of the fifteen recommendations presented to them.

Findings

Tables 2 and 3 (appended pp. 113-114) present the data obtained for the responses of the five samples to the fifteen recommendations extracted from the relevant S-E-T literature.

The suggestion receiving the highest overall support (from 90.7% of the 740 respondents) is item (1) - *introducing more real life skills into science-technology*, followed by item (8) - *more self-discovery*; and item (13) - *promotion of S-E-T careers*.

The patterns of concurrent responses reported between the samples in Table 2 are also consistent with those reported in Table 3. All five samples tend to disagree most strongly with the items emphasising (2) - *gender issues* - and (15) - *the learning of S-E-T through African indigenous culture, world view, technology and thought systems*.

Qualitative findings

In 1997 a final section of the questionnaire (Appendix 2) encouraged respondents to give reasons for choosing their two best and the two least important policy recommendations.

One reason given by the Setswana science teachers for the high response rate for item (1) was that the introduction of real life skills in S-E-T will enable the students to get a better understanding of the meaning of science and technology and its influence in their daily lives. For example:

Introducing more real life skills in science will enable students to view it as part of their daily life experiences which make science easier to comprehend.

The main reasons stated for a high response rate for item (8) - *making more use of self-discovery and self-teaching* - was that it is one of the ways in which S-E-T can encourage students to be more interested in science/technology careers. The following are some of the reasons given by the respondents for favouring item 8:

Its easier for pupils if some of the things are self-discovered.

Science is all about discovery; now what better way than for pupils to actually find out on their own. This arouses their interest and gives them pride in what they do.

Many Setswana teachers of science/technology viewed item (2) - *addressing gender issues* - as re-introducing gender discrimination, irrelevant to science teaching and a waste of time. The following statements were often given:

Discrimination with regard to gender is not of importance. Science is for all pupils.

I do not think gender issues are relevant in science.

Paying more attention to gender issues in Science is a waste of time as the curriculum does not discriminate.

Several reasons were offered for not favouring item (5) - *paying more attention to language issues*. The most recurrent ones were the following:

Terminology will be a problem as I believe science is international. Cultural and traditional factors are of lesser importance.

Indigenous languages are poorly developed in the Republic of South Africa - No textbooks are available in these languages. Hence, such languages can never be used effectively as a teaching medium.

All the reasons given by Setswana science teachers seemed to favour the use of English as a medium of instruction for science/technology.

The open ended section also required the respondents to give other suggestions for improving science/technology in South Africa. The majority of the respondents required *more teacher in-service education and teacher upgrading programmes* in the areas of science/technology. This recommendation agrees with the government decision to budget affirmatively for the training of science and technology teachers in historically disadvantaged high schools [11]. There was also a need among the respondents for *more laboratory equipment in schools*, which is also consistent with the findings by Wilkinson [7].

Discussion

The relatively strong demand for item (12) - *more computer-aided instruction* - as a priority by the school science pupils (samples 2 and 4) is not shared by their science/technology teachers, lecturers and science-teachers-in-training (samples 1, 3 and 5) in this study. A more extensive investigation would be required to clarify the apparent lack of congruence between the preferences of young scientists and their adult mentors in South Africa.

Reasons might also be sought for the highest rejection of item (15) - *increased use of African indigenous technology* - occurring among sample 3 (60% rejection rate); and for the relatively low preference given by the samples of younger science respondents to item (5) which recommends paying more attention to *language issues, technical terms, word meanings and scientific English* as a secondary language. Among the reasons given by the North West rural science teachers for the low preference for item (5) however was that South Africans should be able

to communicate internationally, and the only way to do that is to use English as a medium of instruction. Concerns were also raised about the translation of the English science terminology into Setswana and other indigenous languages as the meaning may be lost. More in-depth study needs to be done to probe further the rejection of item (5) as pioneers of language teaching in science seem to disagree with the views of samples 2, 3, 4 and 5.

Although, according to two independent critics, the content wording of the pilot instrument in Appendix 2 might be improved or clarified in some respects in items (1), (9), (10) and (12), many S-E-T planners, teachers and students have sought and used the instrument, finding the overall trends discovered in their classes to be both interesting and useful for curriculum policy development in their schools, technikons and universities in 1996 and 1997.

The findings reported in Tables 2 and 3 (pp. 113-114) also suggest preliminary empirical corroboration, in a diversity of South African contexts, for government suggestions that science and technology education might do well to focus on introducing *more real life skills* into science; and also to encourage the growth of *independent learning skills and self-discovery and individual creativity* in S-E-T. At the same time, the need to recognise a diversity of individual group preferences is also apparent. For example, one S-E-T sample may highly prioritise the need for more computer-aided science learning, whereas students in another group may rank the importance of more primary school-based science and technology as being the *greater need, in their view*.

CONCLUSION

Across a distance of about 2,000 kilometres, a large measure of concurrence has been found between the policy choices of five samples of S-E-T lecturers, teachers and students recently recommended for the national development of science/technology education in the new South Africa. Strong intergroup agreement has been found to exist for the most favoured and least favoured future courses of recommended action, across the Republic of South Africa.

On page 53 of the 1996 *Review Report* of the Institute of Engineers, Australia is the following statement:

We conclude that there is more important work remaining to be done to provide engineering educators with understanding of the attitudes, values and aspirations of high school students in the context of engineer-

ing as a possible career [57].

Furthermore, the ninth recommendation of the 1996 *Report Summary* of IEAust reads as follows:

School and community liaison must be enhanced so that more students choose engineering.

Recommendation 9:

That IEAust, ACED and ATSE with industry assistance, in parallel with changes to engineering education, develop strategies to increase the number of school students seeking a career in engineering, such strategies to include:

- *setting up engineering-related network in high schools for students and parents;*
- *contributing to school curriculum committees and education boards;*
- *reviewing the resources for, and positively influencing the teaching of mathematics, science and technology in primary and secondary schools so that students are better prepared for, and are more predisposed towards science and engineering careers;*
- *providing more work experience opportunities for school students;*
- *developing and supporting the production of relevant informative material in printed and electronic format; and*
- *developing communication with school teachers and career counsellors and those who are being educated for these occupations [58].*

The empirical data presented in this paper, which has been emerging out of studies in science, engineering and technology education in Africa during 1996 and 1997, can, we believe, make more focused contribution to the steps being taken by the enthused leadership of engineering educators in their global mission of sustaining the growth and development of science, engineering and technology in a diversity of cultures, schools, technikons and universities across the world.

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BIOGRAPHY



Kevin Rochford is an Associate Professor of Science Education at the University of Cape Town. He graduated with a BSc from Melbourne University, and gained a BEd with distinction from the University of Cape Town, an MEd with distinction, and a PhD, also from the University of Cape

Town in 1984. He has received more than 20 academic awards and medals, including the Australasian Association for Engineering Education's Medal (International) for distinguished Contributions to Engineering Education (1996); an Excellence in Classroom Teaching Award from the South African Association of Teachers of Physical Science, Mathematics and Biology (1993); the University of Sydney's Norman I. Price Visiting Researcher's scholarship in Electrical Engineering Education (1991); the University of Natal's Visiting Lecturer's Award (1989); UCT's class medal in Astronomy (1975); the George Amos Award for Science Teaching, of the Victorian Council of Schools Organisations, Australia (1967); etc.

He has co-authored more than 100 publications in science and engineering education. He is an active member of the International Advisory Board of the Australasian Journal of Engineering Education, and of the Global Journal of Engineering Education. He has been an active international member of the Australasian Association for Engineering Education since 1989; is a foundation member of the International Liaison Group for Engineering Education; is an active member of the South African Association for Research and Development in Higher Education and the Centre for Research in Engineering Education at the University of Cape Town.

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files of young talented science and mathematics enthusiasts; congruence between the responses of interest groups to government policy statements on science and technology; students with learning disabilities, handicaps and disorders; creative and innovative teaching methods; and the successful acquisition of research skills by historically disadvantaged graduate students.



Zoleka Sokopo is attached to the Science Education Department of the University of Cape Town and to the North West Province as a co-ordinator for science subject advisors.



Chris Kleinsmith has been a member of the Science Education Unit's technical staff at the University of Cape Town for 16 years. He has been substantively involved with the data collection, assembly and computational aspects of this work.

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Table 3: Congruence between the policy preferences of 740 science/technology lecturers, teachers and students in the New South Africa.

Suggestions for Improvement	Graduate S-E-T teachers & lecturers (N=49)		Young scientists & technologists (N=58)		Tsonga-speaking science college students (N=205)		Afrikaans/English bilingual school science pupils in years 8 & 9 (N=314)		Setswana-speaking rural science teachers (N=114)	
	best	least	best	least	best	least	best	least	best	least
1. More real life skills in S-E-T	25	0	17	1	52	10	65	22	54	2
2. More gender issues in S-E-T	0	18	2	24	10	45	29	79	0	59
3. More environmental issues	6	1	7	3	18	23	37	28	7	14
4. S-E-T for community development	5	2	7	0	17	18	18	22	8	8
5. More attention to language	8	3	1	20	5	56	14	95	2	52
6. More focus on the disadvantaged	2	5	4	4	9	21	22	36	78	5
7. More competitions in S-E-T	2	16	15	6	14	33	27	38	19	3
8. More self-discovery in S-E-T	18	0	17	3	59	15	43	20	43	5
9. Core plus options curriculum	2	2	7	5	21	34	54	14	16	9
10. More primary school S-E-T	6	3	9	5	96	10	34	29	26	0
11. Wider community consultations	0	7	0	4	14	27	13	22	7	10
12. Computer-aided instruction	2	6	17	2	34	11	68	14	16	4
13. Promoting careers in S-E-T	5	1	4	4	41	23	31	14	9	5
14. Excitement and adventure	9	1	4	5	9	21	27	15	6	6
15. African indigenous science	0	18	4	18	11	62	20	62	4	37

APPENDIX 1

REASONS FOR NOT REGISTERING FOR SCIENCE AT TERTIARY LEVEL

Please mark the categories that apply to you:

Gender:	<input type="checkbox"/> MALE	<input type="checkbox"/> FEMALE
Is science one of your subjects?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
If so, do you intend studying science at tertiary level?	<input type="checkbox"/> YES	<input type="checkbox"/> NO

Dear student, this is not a test, but a questionnaire to find the reason why students avoid science subjects at tertiary level (including engineering, medicine, etc.).

Please rank the following ten reasons in order of importance to you. Mark the most important 1, mark the least important 10. Please do not repeat numbers.

- Lack of school practical work because of ill-equipped school laboratory.
- My teachers do not explain Science clearly to me.
- I think Science is too expensive to study at tertiary level.
- Although I understand Science when it is being thought, I underperform (I fail).
- The subject is too difficult for me.
- I find practicals boring.
- To enter tertiary education for science or medicine or engineering, you need high marks.
- Science needs a lot of time and concentration to study.
- I lack the necessary scientific background knowledge.
- The language used in Science is difficult to understand.

APPENDIX 2 (Instrument adapted for a specific region)

NORTH WEST DEPARTMENT OF EDUCATION

CIRCLE

MALE	FEMALE
------	--------

COMPUTERS
GEOGRAPHY
TECHNOLOGY
PHYSICAL SCIENCE
BIOLOGY

IMPROVING SCIENCE/ TECHNOLOGY IN THE NORTH WEST PROVINCE

As part of the Reconstruction and Development Programme, I think in the North West Science/ Technology can be improved by:

- | | CIRCLE | |
|--|--------------|-----------------|
| | <u>AGREE</u> | <u>DISAGREE</u> |
| 1. INTRODUCING MORE REAL LIFE SKILLS INTO SCIENCE
(eg technical, trade, industrial, commercial, farming, mining, manufacturing, marketing and technological skills). | [A] | [B] |
| 2. PAYING MORE ATTENTION TO GENDER ISSUES (men and women in science; topics that cater for girls' interest and boys' interest; solutions to the existing gender problems in the North West). | [A] | [B] |
| 3. CONCENTRATING MORE ON NORTH WEST ENVIRONMENTAL ISSUES (eg problems of soil loss and possible solutions, health care, sanitation, air pollution, electrical supply, conservation of plant and animal species). | [A] | [B] |
| 4. USING THE SCIENCES TO ADVANCE AND DEVELOP THE NORTH WEST COMMUNITY SOCIALLY AND ECONOMICALLY (eg to help solve political, labour, citizenship, social and ethical problems in the North West). | [A] | [B] |
| 5. PAYING MORE ATTENTION TO LANGUAGE ISSUES IN THE NORTH WEST (such as teaching cultural meaning of scientific terms; teaching of science using the mother-tongue eg Setswana or Afrikaans or English; learning to understand terms and language; scientific English as a second language). | [A] | [B] |
| 6. HAVING THE DISADVANTAGED MAJORITY IN THE NORTH WEST AS ITS FOCAL POINT (ie using science/technology education to empower communities address their local problems resourcefully, eg housing, sanitation etc). | [A] | [B] |
| 7. ENCOURAGING COMPETITIONS , with more enterprises to be organised between schools and within schools in the North West (eg students participating in EXPO, science fairs, science Olympiad, science essay writing etc). | [A] | [B] |
| 8. MAKING MORE USE OF SELF-DISCOVERY AND SELF-TEACHING (ie students designing their own experiments and fieldwork and developing skills for problem solving, creative thinking etc). | [A] | [B] |

9. **CHANGING CURRICULA TO A COMPULSORY BASIC SYLLABUS PLUS OPTIONS** (ie students do compulsory science modules and choose others freely and individually for their own personal relevance and interest). [A] [B]
10. **GIVING ALL PUPILS IN THE PRIMARY SCHOOLS IN THE NORTH WEST MUCH MORE BASIC SCIENCE AND TECHNOLOGY** than they receive presently. [A] [B]
11. **ALL INTERESTED GROUPS IN THE NORTH WEST SHOULD BE CONSULTED** on how they think science can be improved in schools. [A] [B]
12. **USING COMPUTER-AIDED INSTRUCTION AND COMPUTER INTERFACING AS PART OF SCIENCE EXPERIMENTS** (eg to collect, display, analyse and plot data; and to explain science concepts). [A] [B]
13. **PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY AMONG SCHOOL PUPILS IN THE NORTH WEST.** [A] [B]
14. **SHARING AND INCREASING THE INTELLECTUAL EXCITEMENT AND SENSE OF ADVENTURE WHICH THE SCIENCE OFFERS** (its benefits, optimism, encouragement, spirit and challenge to the North West pupils). [A] [B]
15. **LEARNING SCIENCE THROUGH THE AFRICAN INDIGENOUS TECHNOLOGY AND CULTURE, AND THROUGH THE AFRICAN WORLD VIEW OF LIFE AND THOUGHT SYSTEM** (ie preserving what is good in African culture and tradition; regarding science as sacred; learning science through African theories of space and time, the kinship system, customs, images, symbols, forms of expression, values, feelings and interpretations). [A] [B]
- (a) **THE TWO BEST WAYS OF IMPROVING SCHOOL SCIENCE/TECHNOLOGY IN THE NORTH WEST PROVINCE MENTIONED ABOVE ARE NUMBERS () AND ().**
- (b) **THE TWO LEAST IMPORTANT RECOMMENDATIONS MENTIONED ABOVE ARE NUMBERS () AND ().**

ON THE BACK OF THIS SHEET YOU MAY WISH TO GIVE REASONS FOR SOME OF YOUR ANSWERS, OR YOU MAY WISH TO MAKE OTHER SUGGESTIONS FOR IMPROVING SCIENCE IN THE NORTH WEST PROVINCE.

Circle AGREE or DISAGREE for each item

KEY: [A] = AGREE

[B] = DISAGREE

1. Reasons for choosing numbers _____ and _____ as the two best ways for improving Science/Technology in the North West Province are _____

2. Reasons for choosing numbers _____ and _____ as the two least important recommendations for improving Science/Technology in the North West are _____

3. What other suggestions can you give for improving Science /Technology in the North West? Please give reasons for your answer.

THANK YOU

APPENDIX 2

Photocopies of some of the suggestions made by the respondents during the developmental studies of potential instruments

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXFO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

() Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science.

() The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)

(4) The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial ~~skills~~, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

() An improvement could be to concentrate more on current South African environmental crises ^{problems and solutions} (problems of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)

(3) Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, ^{by looking into solutions to solve} and solve political, labour, citizenship and ethical problems in society.

() The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.)

() Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.

() More competitions and enterprises could be encouraged between schools and within schools.

(2) More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

(5) Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

() The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

() Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills.

() All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

Same as
category
5

() The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

each item

→ sentence too long

University of Cape Town

Improvement / leads to confusion

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXFO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

- ✓ (7) Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science.
 - () The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)
- ✓ (6) The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.
- ✓ (1) An improvement could be to concentrate more on current South African environmental crises (problems of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)
- ✓ (9) Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, and solve political, labour, citizenship and ethical problems in society.
 - () The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.)
 - () Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.
 - () More competitions and enterprises could be encouraged between schools and within schools.
- ✓ (3) More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.
- ✓ (4) Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

() The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

(6) Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills. } same as 9.

() All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

(1) The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

Too long. sentences

Seperate ranking bracket

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IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXFO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

() Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science. *[Explain African] No room for a person who needs both*

() The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)

() The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

() An improvement could be to concentrate more on current South African environmental crises (~~problems~~^{e.g.} of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)

{ () Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, and solve political, labour, citizenship and ethical problems in society.

() The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.)

{ () Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.

() More competitions and enterprises could be encouraged between schools and within schools.

() More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

() Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

() The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

() Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing ^{skills} ~~thinking skills~~, creativity ~~skills~~, problem-solving ~~skills~~ and fieldwork ~~skills~~.

() All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

() The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

University of Cape Town

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXPO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

() Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science.

() The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)

() The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

() An improvement could be to concentrate more on current South African environmental crises (problems of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)

() Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, and solve political, labour, citizenship and ethical problems in society.

() The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.) remove

() Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to ~~make up for a lack of equipment and resources in some schools.~~ *empower our communities to address their own local problems.*

() More competitions and enterprises could be encouraged between schools and within schools. remove

() More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

() Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

(2) The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

(3) Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills.

() All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

() The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

- ① Keep to the key terms and keep their explanations in parentheses.
- ② Link nos 5 of the last one.
- ③ Paragraphs too long.

2000/1951-

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXPO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

() Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science.

(8) The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)

(7) The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

(3) An improvement could be to concentrate more on current South African environmental crises (problems of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)

(5) Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, and solve political, labour, citizenship and ethical problems in society.

() The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.)

(6) Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.

least () More competitions and enterprises could be encouraged between schools and within schools.

(4) More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

(1) Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

- 11 () The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.
- 12 () Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills. *combine with 9.*
- 13 () All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.
- 14 () The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

University of Cape Town

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXPO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

1 () Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science.

2 () The sciences can be improved in schools by paying more attention to gender issues (men and women in ~~mathematics/science~~ ^{highlight problems}; ~~mathematics and science topics for both girls' interests and boys' interests, -etc.~~) ^{AS}

3 () The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

4 () An improvement could be to concentrate more on current South African environmental crises (problems of soil loss, ^{issues} health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.) ^{not solved}

5 () Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, ~~and solve political~~, labour, citizenship and ethical problems in society.

6 () The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.) ^{ie learning to understand the terms & language}

7 () Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.

8 () More competitions and enterprises could be encouraged between schools and within schools. ^{Deep?}

9 () More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

10 () Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

9+12
combined
? () The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

() Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills.

2x () All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

with (S) ✓ () The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

University of Cape Town

IMPROVING SCIENCE/MATHEMATICS/TECHNOLOGY IN THE NEW SOUTH AFRICA

As an EXPO entrant, and as a young science/mathematics enthusiast in the New South Africa, my recommendations for improving the learning of the sciences in South African schools, as part of the Reconstruction and Development Programme, numbered in order of importance, are as follows:-

Technology
() Improvements can occur by giving more attention to special African topics in the sciences and less attention to topics of common international interest in mathematics/science. *change*

X () The sciences can be improved in schools by paying more attention to gender issues (men and women in mathematics/science; mathematics and science topics for both girls' interests and boys' interests, etc.)

✓ () The mathematics/sciences can be improved in schools by introducing more technical skills, trade skills, industrial skills, manufacturing skills, marketing skills, and technological skills in real life situations; and having less academic/book learning.

✓ () An improvement could be to concentrate more on current South African environmental crises (problems of soil loss, health care, sanitation, air pollution, electricity supply, destruction of plant and animal species, etc.)

✓ () Improvements could occur by using mathematics/science to help the community to develop itself socially and economically, and solving political, labour, citizenship and ethical problems in society.

Don't change context
() The sciences can be improved in schools by paying more attention to language issues (technical terms, mother-tongue instruction, cultural meanings of words, learning at the proper level of understanding, English as a second language, etc.)

✓ () Mathematics/science can be improved in schools by having the disadvantaged South African majority as its focal point, with the government using education to make up for a lack of equipment and resources in some schools.

✓ () More competitions and enterprises could be encouraged between schools and within schools.

✓ () More use could be made of self-discovery and self-teaching methods in mathematics/science, with students designing more of their own experiments and inventions.

✓ () Science/mathematics curricula could be changed to have a small, compulsory core syllabus plus many free choice options which students could choose individually for their own personal relevance and pleasure.

() The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present.

✓(8) Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills.

✓(5) All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

✓(2) The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

Items too long → confusing.
Instructions too long
Need to refine → shorten the sentences
Many repetitive leading words, e.g. increasingly, sci
(—)

(12) The mathematics/sciences could be improved by giving all pupils in the primary schools much more science and technology than they receive at present. — keep options Uniform.

(13) Less time could be spent learning existing mathematics/science textbook facts and more time could be spent developing thinking skills, creativity skills, problem-solving skills and fieldwork skills.

(10) All interested groups in the communities should be consulted for suggestions on how they think mathematics/science can be improved in schools.

Prop ⇒

(14) The mathematics/sciences can be improved in schools by seeing and feeling and experiencing them in a more "human" way, (i.e. maths/science/technology should not appear to be merely as an objective, neutral, impersonal body of knowledge).

It is going to change with each new Ideology by a new Group.

University of Cape Town

APPENDIX

3a

The 17-item survey instrument

University of Cape Town

CIRCLE

MALE	FEMALE
------	--------

COMPUTERS
GEOGRAPHY
TECHNOLOGY
PHYSICAL SCIENCE
BIOLOGY

IMPROVING SCIENCE/ TECHNOLOGY IN THE SOUTH AFRICA

As part of the Reconstruction and Development Programme, I think in the South Africa Science/ Technology can be improved by:-

- | | CIRCLE | |
|--|--------|----------|
| | AGREE | DISAGREE |
| <p>1. INTRODUCING MORE REAL LIFE SKILLS INTO SCIENCE
(e.g. technical, trade, industrial, commercial, farming, mining, manufacturing, marketing and technological skills).</p> | [A] | [B] |
| <p>2. PAYING MORE ATTENTION TO GENDER ISSUES
(men and women in science; topics that cater for girls' interest and boys' interest; solutions to the existing gender problems in South Africa).</p> | [A] | [B] |
| <p>3. CONCENTRATING MORE ON SOUTH AFRICA ENVIRONMENTAL ISSUES (e.g. problems of soil loss and possible solutions, health care, sanitation, air pollution, electrical supply, conservation of plant and animal species).</p> | [A] | [B] |
| <p>4. USING THE SCIENCES TO ADVANCE AND DEVELOP THE SOUTH AFRICACOMMUNITY SOCIALLY AND ECONOMICALLY (e.g. to help solve political, labour, citizenship, social and ethical problems in South Africa).</p> | [A] | [B] |
| <p>5. PAYING MORE ATTENTION TO LANGUAGE ISSUES IN THE SOUTH AFRICA(such as teaching cultural meaning of scientific terms; teaching of science using the mother-tongue e.g. Setswana or Afrikaans or English; learning to understand terms and language; scientific English as a second language).</p> | [A] | [B] |
| <p>6. HAVING THE DISADVANTAGED MAJORITY IN SOUTH AFRICA AS ITS FOCAL POINT(i.e. using science/technology education to empower communities address their local problems resourcefully, e.g. housing, sanitation etc.).</p> | [A] | [B] |
| <p>7. ENCOURAGING COMPETITIONS, with more enterprises to be organised between schools and within schools in South Africa (e.g. students participating in Expo, science fairs, science Olympiad, science essay writing etc.).</p> | [A] | [B] |
| <p>8. MAKING MORE USE OF SELF-DISCOVERY AND SELF-TEACHING (i.e. students designing their own experiments and fieldwork and developing skills for problem solving, creative thinking etc.).</p> | [A] | [B] |

9. **CHANGING CURRICULA TO A COMPULSORY BASIC SYLLABUS PLUS OPTIONS** (i.e. students do compulsory science modules and choose others freely and individually for their own personal relevance and interest). [A] [B]
10. **GIVING ALL PUPILS IN THE PRIMARY SCHOOLS IN SOUTH AFRICA MUCH MORE BASIC SCIENCE AND TECHNOLOGY** than they receive presently. [A] [B]
11. **ALL INTERESTED GROUPS IN THE SOUTH AFRICA SHOULD BE CONSULTED** on how they think science can be improved in schools. [A] [B]
12. **USING COMPUTER-AIDED INSTRUCTION AND COMPUTER INTERFACING AS PART OF SCIENCE EXPERIMENTS** (e.g. to collect, display, analyse and plot data; and to explain science concepts). [A] [B]
13. **PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY AMONG SCHOOL PUPILS IN SOUTH AFRICA.** [A] [B]
14. **SHARING AND INCREASING THE INTELLECTUAL EXCITEMENT AND SENSE OF ADVENTURE, WHICH THE SCIENCE OFFERS** (its benefits, optimism, encouragement, spirit and challenge to South African pupils). [A] [B]
15. **LEARNING SCIENCE THROUGH THE AFRICAN INDIGENOUS TECHNOLOGY AND CULTURE, AND THROUGH THE AFRICAN WORLD VIEW OF LIFE AND THOUGHT SYSTEM** (i.e. preserving what is good in African culture and tradition; regarding science as sacred; learning science through African theories of space and time, the kinship system, customs, images, symbols, forms of expression, values, feelings and interpretations) [A] [B]
- (a) THE **TWO BEST** WAYS OF IMPROVING SCHOOL SCIENCE/TECHNOLOGY IN SOUTH AFRICA MENTIONED ABOVE ARE NUMBERS () AND ().
- (b) THE **TWO LEAST IMPORTANT** RECOMMENDATIONS MENTIONED ABOVE ARE NUMBERS () AND ().

ON THE BACK OF THIS SHEET YOU MAY WISH TO GIVE REASONS FOR SOME OF YOUR ANSWERS, OR YOU MAY WISH TO MAKE OTHER SUGGESTIONS FOR IMPROVING SCIENCE IN THE SOUTH AFRICA.

Circle AGREE or DISAGREE for each item

KEY: [A] = AGREE

[B] = DISAGREE

P. T. O.

1. Reasons for choosing numbers _____ and _____ as the two best ways for improving Science/Technology are _____

2. Reasons for choosing numbers _____ and _____ as the two least important recommendations for improving Science/Technology are _____

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers?

THANK YOU

APPENDIX

3b

A localised 17-item survey instrument

University of Cape Town

(Instrument adapted for a specific region)

NORTH WEST DEPARTMENT OF EDUCATION

CIRCLE

MALE	FEMALE
------	--------

COMPUTERS
GEOGRAPHY
TECHNOLOGY
PHYSICAL SCIENCE
BIOLOGY

IMPROVING SCIENCE/ TECHNOLOGY IN THE NORTH WEST PROVINCE

As part of the Reconstruction and Development Programme, I think in the North West Science/ Technology can be improved by:-

	<u>CIRCLE</u>	
	<u>AGREE</u>	<u>DISAGREE</u>
1. INTRODUCING MORE REAL LIFE SKILLS INTO SCIENCE (e.g. technical, trade, industrial, commercial, farming, mining, manufacturing, marketing and technological skills).	[A]	[B]
2. PAYING MORE ATTENTION TO GENDER ISSUES (men and women in science; topics that cater for girls' interest and boys' interest; solutions to the existing gender problems in the North West).	[A]	[B]
3. CONCENTRATING MORE ON NORTH WEST ENVIRONMENTAL ISSUES (e.g. problems of soil loss and possible solutions, health care, sanitation, air pollution, electrical supply, conservation of plant and animal species).	[A]	[B]
4. USING THE SCIENCES TO ADVANCE AND DEVELOP THE NORTH WEST COMMUNITY SOCIALLY AND ECONOMICALLY (e.g. to help solve political, labour, citizenship, social and ethical problems in the North West).	[A]	[B]
5. PAYING MORE ATTENTION TO LANGUAGE ISSUES IN THE NORTH WEST (such as teaching cultural meaning of scientific terms; teaching of science using the mother-tongue e.g. Setswana or Afrikaans or English; learning to understand terms and language; scientific English as a second language).	[A]	[B]
6. HAVING THE DISADVANTAGED MAJORITY IN THE NORTH WEST AS ITS FOCAL POINT (i.e. using science/technology education to empower communities address their local problems resourcefully, e.g. housing, sanitation etc.).	[A]	[B]
7. ENCOURAGING COMPETITIONS , with more enterprises to be organised between schools and within schools in the North West (e.g. students participating in EXPO, science fairs, science Olympiad, science essay writing etc.).	[A]	[B]
8. MAKING MORE USE OF SELF-DISCOVERY AND SELF-TEACHING (i.e. students designing their own experiments and fieldwork and developing skills for problem solving, creative thinking etc.).	[A]	[B]

9. **CHANGING CURRICULA TO A COMPULSORY BASIC SYLLABUS PLUS OPTIONS** (i.e. students do compulsory science modules and choose others freely and individually for their own personal relevance and interest). [A] [B]
10. **GIVING ALL PUPILS IN THE PRIMARY SCHOOLS IN THE NORTH WEST MUCH MORE BASIC SCIENCE AND TECHNOLOGY** than they receive presently. [A] [B]
11. **ALL INTERESTED GROUPS IN THE NORTH WEST SHOULD BE CONSULTED** on how they think science can be improved in schools. [A] [B]
12. **USING COMPUTER-AIDED INSTRUCTION AND COMPUTER INTERFACING AS PART OF SCIENCE EXPERIMENTS** (e.g. to collect, display, analyse and plot data; and to explain science concepts). [A] [B]
13. **PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY AMONG SCHOOL PUPILS IN THE NORTH WEST.** [A] [B]
14. **SHARING AND INCREASING THE INTELLECTUAL EXCITEMENT AND SENSE OF ADVENTURE, WHICH THE SCIENCE OFFERS** (its benefits, optimism, encouragement, spirit and challenge to the North West pupils). [A] [B]
15. **LEARNING SCIENCE THROUGH THE AFRICAN INDIGENOUS TECHNOLOGY AND CULTURE, AND THROUGH THE AFRICAN WORLD VIEW OF LIFE AND THOUGHT SYSTEM** (i.e. preserving what is good in African culture and tradition; regarding science as sacred; learning science through African theories of space and time, the kinship system, customs, images, symbols, forms of expression, values, feelings and interpretations) [A] [B]
- (a) THE **TWO BEST** WAYS OF IMPROVING SCHOOL SCIENCE/TECHNOLOGY IN THE NORTH WEST PROVINCE MENTIONED ABOVE ARE NUMBERS () AND ().
- (b) THE **TWO LEAST IMPORTANT** RECOMMENDATIONS MENTIONED ABOVE ARE NUMBERS () AND ().

ON THE BACK OF THIS SHEET YOU MAY WISH TO GIVE REASONS FOR SOME OF YOUR ANSWERS, OR YOU MAY WISH TO MAKE OTHER SUGGESTIONS FOR IMPROVING SCIENCE IN THE NORTH WEST PROVINCE.

Circle AGREE or DISAGREE for each item

KEY: [A] = AGREE

[B] = DISAGREE

P. T. O.

1. Reasons for choosing numbers _____ and _____ as the two best ways for improving Science/Technology are _____

2. Reasons for choosing numbers _____ and _____ as the two least important recommendations for improving Science/Technology are _____

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers?

THANK YOU

APPENDIX 4

A Xhosa version of the 17-item survey
instrument

University of Cape Town

IBANGA	
6-8	9-10

UMNTU OBHINQILEYO
INDODA

IZIBALO
IIKHOMMPYUTHA
IJOGRAFI
INZULULWAZI NGOBUGCISA
IFIZIKISI
IBHAYOLOJI

**UNYUSO-MGANGATHO LWEZENZULULWAZI/IZIBALO/NENZULULWAZI
NGEZOBUGCISA KUMZANTSI AFRIKA OMTSHA**

Ngokubhekiselele kwinkqubo yophuhliso nophuculo mgangatho
Ndinga okokuba ufundiso lwezibalo nenzuluwazi ezikolweni lunga-phuculwa ngokuthi:

RHANGGQELA
NDIYAVUMA ANDIVUMI

- UKUFAKA OBONE BUCHULE BOBOMI KWEZE NZULULWAZI**
(umzkl. Inzululwazi ngezobugcisa, urhwebo,
amashishini, intengiso, ukwenziwa kwezinto ezifektri, [NDI] [ANDI]
nobuchule kwezobugcisa)
- UKUTHATHELA INGOALELO UMCIMBI WOBUNI**
(Umzkl. Amadoda nabafazi kwiZibalo/iNzululwazi/neNzululwazi,
ngezobugcisa; izihloko ngezinto ezinika umdla kumantombazana
namakhwenkwe; izisombululo kwiingxaki ezikhoyo ngobuni, [NDI] [ANDI]
njl-njl.)
- UKUNIKA ILISO IKAKHULU KWIZINTO ZENDALO EMZANTSI-AFRIKA**
(Njengeengxaki zokungakhathalelwa komhlaba
nesisombululo, ukukhathalelwa kwempilo, ezococeko, ungcolisio
lomoya, ubonelelo ngombane, ulondolozo lomhlaba noluhlu [NDI] [ANDI]
lwezilwanyana, njl-njl.)

4. **UKUSEBENZISA EZENZULULWAZI JIKELELE NOKUNYUSA UMZI NGOKWASENTLALWENI NAKWEZOQOQOSH.**
(Umzkl, ukunceda ekusombululeni iingxaki ezibhekiselele [NDI] [ANDI]
kwezombuso, emisebenzini, kubumi, ekuhlaleni nakwimikhwa
esesikweni)
5. **UKUTHATHELA INGOALELO UMCIMBI WEELWIMI**
(Njengamagama obuchule, imigaqo yolwimi lokuzalwa,
intsingiselo echubekileyo yamagama eNzululwazi, ukufunda [NDI] [ANDI]
nokuwalandela kakuhle amagama nolwimi, ukufundwa
kwesilungu njengolwimi lwesibini, njl-njl.)
6. **UKWENZA INXALENYE YABO BANGAZANGE BALIFUMANA ITHUBA KUMZANTSI AFRIKA BABENGOYENGA NDOOO KWEZI ZIFUNDO,**
ukusebanzisa le mfundo ukunyusa umgangathho wokuhlala [NDI] [ANDI]
nakuhlangabenzana neengxaki zokuhlala ngobuqili
7. **UKUKHUTHAZA UKHUPHISWANO NGAKUMBI**
kwenziwe ukhuphiswanu loshishino lwezikolo [NDI] [ANDI]
(ngaphandle nanagaphakathi ezikolweni)
8. **UKWENZA UKUBA ABANTU BASEBENZISE IINGCINGA NEENGOIQO EZIZEZABO**
(Umzkl. Abafundi basebenzise abakwaziyo nabakubonayo
kuphando olulolwabo, babenobuchule bokusombulula iingxaki [NDI] [ANDI]
ngokunokwabo, basebenzise iziphiwo zabo zokuyila
nokucinga, njl-njl)
9. **UKUGUQULA ULUDWE LWEZIFUNDO (IKHARIKYULAM) LUBE LUQINGQO LWEZIFUNDO (ISILABHASI) OLUNYANZELEKILEYO KWAKUNYE NOLUNGANYANZELEKANGA,** [NDI] [ANDI]
apho abafundi bakubanalo ilungelo lokuzikhethela ngokuphathelele
kwiimbono neemfuno zabo.
10. **UKUNIKA BONKE ABAFUNDI ABASEKUMABANGA APHANTSI**
olona lwazi lususiseko lweNzululwazi, kunokuba belufumana [NDI] [ANDI]
okweli lixa (oko kukuthi phambi kokuba baye kumabanga
aphakamileyo).

11. **ONKE AMAQELA NGAMAQELA ASEKUHLALENI ANOMDLA KWEZI ZIFUNDO MAKAMENYWE.** [NDI] [ANDI]
kujongwe indlela acinga ngayo ngeZibalo/iNzululwazi/kwakunye neNzululwazi ngezobugcisa ezikolweni kulo nyaka.
12. **UKUSEBENZISA ULWAZI OLUGCINWA KOOMATSHINI NJENGENXENYE YOMFUNISELO WENZULLULWAZI** [NDI] [ANDI]
(Umzkl. Ukuqokelela, ukubonisa, ukudibanisa, ukuchonga kwakunge nokuyila ulwazi)
13. **UKUKHUTHAZA INKQUBELA-PHAMBILI YOBOMI KWI-**
Nzululwazi/iZibalo kwakunye neNzululwazi [NDI] [ANDI]
ngobugcisa kubafundi
14. **UKWABELANA NOKWANDISA IMVUSELELEKO YENGOONDO NOBULUMKO BODELONGOZI OLUNIKWA YINZULULWAZI.** [NDI] [ANDI]
(Umzkl. ithemba, uncedo, ukulindela okuhle, inkuthazo, umoya omhle kwakunye nokucela umngeni)
15. **UKUFUNDA INZULULWAZI NGEZINTO ZOBUCHULE UBUGCISA KWAKUNYE NENKCUBEKO YASE AFRIKA, ?MBONO ZELIZWE LASE-AFRIKA NGOBOMI NANGENGOIQO EMISIWEYO** [NDI] [ANDI]
(oko kukuthi ukugcina okona kulungileyo ngenkcubeko kunye namasiko ase-Afrika, iNzululwazi ithathwe njengento engcwele, kufundwe iNzululwazi ngeengcinga zase-Afrika ngokuphangaleleyo, iingcinga ezimiseweyo ngobudlelwane, izithethe, imifanekiso, imiqondiso, iindlela zokubonisa, iinqobo ezisemgangathweni, iimvakalelo kwakunye nenkcazo ngokupheleleyo)

* ezona ndlela zimbini zokuphucula umgangatho weNzululwazi/iZibalo neNzululwazi ngezobugcisa apha ngentla zezi : () No-()

* ezona ndlela zimbini ezingabalulekanga kangako apha ngentla zezi: () No-()

Rhangqela U [ndiyavuma] okanye [andivumi]	
isiboniso	: [ndi] - ndiyavuma : [andi]- andivuvmi

APPENDIX 5

Photocopies of some of the responses for the choice of best/least important policy recommendations, and suggestions on more issues to be included for the improvement of science and technology teaching and learning.

1. Reasons for choosing numbers 7 and 10 as the two best ways for improving

Science in the North West are

1. Science is inescapably a practical subject and as such science fairs, expos and Olympiads are necessary, so that young scientists must be exposed nurtured without waste of time.

2. Reasons for choosing numbers 2 and 5 as the two least important

recommendations for improving Science in the North West are

1. Gender issues in the teaching of Science are irrelevant. Sexism will waste a lot of time.

2. The language issue: English must be the medium of instruction in the teaching of Science in the NWP, so that there should not be problems if a child wants to overseas.

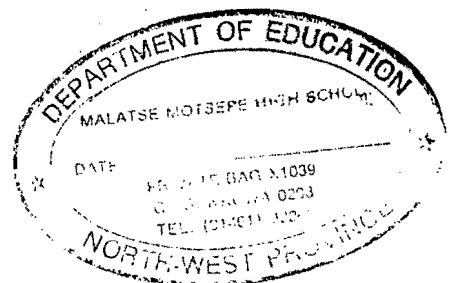
3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

1. Schools must be well equipped with labs and science equipment.

2. Experts in different fields of Science must be called at schools, to give seminars about their respective fields.

3. Educational Excursions: e.g. A visit to S.A.B or CSIR would contribute to the teaching of Science because interest in Pupils would be aroused.

THANK YOU



1. Reasons for choosing numbers ____ and ____ as the two best ways for improving Science in the North West are

Students will understand more if they learn what they experience in life. Also if this is stressed in primary it will help them to enjoy and love the subject.

2. Reasons for choosing numbers ____ and ____ as the two least important recommendations for improving Science in the North West are

It is not that important to look into gender if teaching this subject. Also it is not important to concentrate on language in dealing with this.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

Teachers should be more workshopped as this will benefit the student. Also there should be more competition for student like the Expo that exist - As this could encourage them to work more. Apparatus should be supplied to schools for experiments

THANK YOU

1. Reasons for choosing numbers 1 and 12 as the two best ways for improving

Science in the North West are

that by introducing real life skills into science will increase practical involvement of pupils and develop their interest in careers like farming, mining, commerce etc. and that by using computer-aided instructions and computer-aided aspects of science experiments can help to combat computer illiteracy in disadvantaged communities.

2. Reasons for choosing numbers 5 and 15 as the two least important

recommendations for improving Science in the North West are

that paying more attention to language issues in the northwest like teaching cultural meaning of scientific terms is not of importance to international communities and national science upliftment and although this can on the other hand be helpful in understanding of pupils, this will not work internationally.

3. What other suggestions can you give for improving Science in the North West?
Please give reasons for your answer.

Introducing ~~be~~ exercises for science pupils in each school for at least a best science pupil and this will encourage pupils esp. those in the disadvantaged communities. Supplying scientific apparatus to schools to encourage practical work and interest in pupils esp. disadvantaged communities.

THANK YOU

1. Reasons for choosing numbers 9 and 10 as the two best ways for improving Science in the North West are

1. Because science and technology presently and will in future control our way of living.
2. Opening up career opportunities.
3. Having a better understanding of our lives and the use of our environment and its natural resources.

2. Reasons for choosing numbers 2 and 5 as the two least important recommendations for improving Science in the North West are

Gender and language issues have got nothing to do with science and technology.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

1. Make the curricula relevant to the present and future needs of industries. (career orientated)
2. Upgrading laboratories and maintaining constant supply of apparatus.
3. Upgrading science teachers
4. Preparing learners for employment at school level.

THANK YOU

1. Reasons for choosing numbers 4 and 9 as the two best ways for improving Science in the North West are

During this era we need more scientists who will help to improve the economy of the country, e.g. Children should be so creative as to manufacture our own products with our own materials, instead of importing them. Products like cars; aeroplanes; televisions; etc.

2. Reasons for choosing numbers 2 and 11 as the two least important recommendations for improving Science in the North West are

It is high time that gender discrimination should be completely done away with. Therefore I do not see the reason why there should be specific topics for men & women. It is not possible to meet all the people in the province about how science can/should be taught.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

Schools should be adequately resourced with Science Equipments.
More in-service courses to be conducted for under-qualified teachers, especially the Primary School Teachers.

THANK YOU

1. Reasons for choosing numbers 7 and 10 as the two best ways for improving Science in the North West are

Basics in Science & Technology received in primary schools are lacking and inadequate, therefore improving them and encouraging them would draw their attention more to the field of Science, and this should be supplemented by giving enough bursaries to successful students.

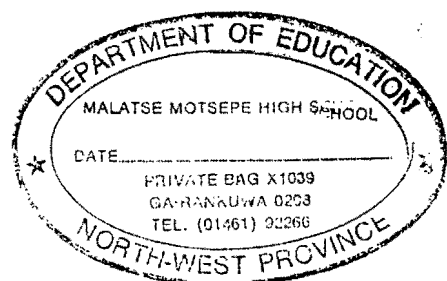
2. Reasons for choosing numbers 2 and 5 as the two least important recommendations for improving Science in the North West are

Paying more attention to gender issues in Science would be a waste of time as the curriculum does not discriminate. Again paying more attention to language issues would take decades to be successful, and in the mean-time, science awareness among the community would be dropping.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

North West should organise seminars and invite experts from different fields of science and students + teachers from schools so as to improve science in this ~~school~~ province. Also by improving basic skills in Science & Tech. in primary school would upgrade this project seriously.

THANK YOU



1. Reasons for choosing numbers 3 and 6 as the two best ways for improving

Science in the North West are

This is simply what we need so as to conserve nature and again improve our living conditions, especially with the disadvantaged community.

2. Reasons for choosing numbers 2 and 5 as the two least important

recommendations for improving Science in the North West are

The use of mother-tongues like Setswana, etc. will complicate things because it is practically impossible to find suitable terms for science especially with complex and awkward terms. Sexism is again not the solution because people with potential may be at a disadvantage simply because of their gender.

3. What other suggestions can you give for improving Science in the North West?
Please give reasons for your answer.

Teaching students through experimentation because what you've discovered on your own "sticks" to your mind more than something that you got from somebody.

THANK YOU

1. Reasons for choosing numbers 6 and 8 as the two best ways for improving

Science in the North West are

People in the disadvantaged communities are not so much interested in science, they take it as a difficult subject because of lack of resources. If their situation is improved by introducing facilities to them we will improve economically and if pupils at school are involved practically in all possible ways.

2. Reasons for choosing numbers and as the two least important

recommendations for improving Science in the North West are

I think gender is not so much a problem to one's achievements scientifically, it's a question of how you project yourself. The African culture of viewing science should be coupled with the western view. In improving science and for us to be have a global view of science.

3. What other suggestions can you give for improving Science in the North West?
Please give reasons for your answer.

I have a view that more of the schools in the N.W. do not have necessary facilities; donations should be obtain and such institutions be supplied with facilities/equipments. Teachers should also be equipped with recent skills on improving their teaching of the sciences.

THANK YOU

1. Reasons for choosing numbers 1 and 9 as the two best ways for improving Science in the North West are

IF THE TEACHING OF SCIENCE MAY BE GEARED TOWARDS EQUIPPING STUDENTS WITH SKILLS THAT WILL MAKE THEM FIT WELL IN THE COMMERCIAL AND INDUSTRIAL WORLD, THEN IT WILL BE VERY RELEVANT. THE NEED FOR SELECTING CERTAIN BASIC TOPICS (COMPULSORY) AND ALLOWING STUDENTS IN GRADES 10-12 TO CHASE THEIR INDIVIDUAL GOALS AS WELL CANNOT BE OVEREMPHASIZED

2. Reasons for choosing numbers 15 and _____ as the two least important recommendations for improving Science in the North West are

ALTHOUGH THE TEACHING OF SCIENCE DOES NOT HAVE TO BE COMPLETELY BASED ON THE AFRICAN CULTURE, BUT THE CHOICE OF CERTAIN RELEVANT ASPECTS OF CULTURE WILL HELP STUDENTS NOT TO UNDERESTIMATE THE IMPORTANCE OF CULTURE AND THIS WILL TO A GREATER EXTENT STIMULATE MORE INTEREST IN THEM.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

EDUCATORS AS THE IMPORTANT HUMAN RESOURCES IN THIS PROCESS, MUST BE ENCOURAGED AND BE AFFORDED OPPORTUNITIES IN TERMS OF TIME AND FINANCES TO EQUIP THEMSELVES TO MEET THIS GREAT CHALLENGE. SHOULD THIS NOT BE CONSIDERED WITH ALL SERIOUSNESS, THIS VERY IMPORTANT PROCESS WILL BE SERIOUSLY HAMPED.

THANK YOU

1. Reasons for choosing numbers 8 and 10 as the two best ways for improving

Science in the North West are

Pupils will come into contact with realities of science and technology at an early age and the usage of self-activity & experiments will actively involve kids in the science subject as such and it will stimulate initiative and interest.

2. Reasons for choosing numbers 2 and 3 as the two least important

recommendations for improving Science in the North West are

Gender issue is NOT THE crux of the high percentage of lack of interest in science subject. But the curriculum which is not linked to daily life, which is more examination orientated is the cause.

3. What other suggestions can you give for improving Science in the North West?
Please give reasons for your answer.

Revise the syllabus and curriculum to make it to be more practical and helpful in life. Motivate science teachers by awarding certificates & appraisal for best achievements, both in their studies and high % of pass rate.

THANK YOU

1. Reasons for choosing numbers 1 and 8 as the two best ways for improving Science/Technology are _____

1) People learn more when they can do things hands-on

2) When out of a classroom environment (teacher speaks while children speak sit) children become creative and learn more

2. Reasons for choosing numbers 9 and 5 as the two least important recommendations for improving Science/Technology are _____

9) If children have a choice to learn or not, most children would not want to learn, so they would not be educated.

5) English is (I think) the most important language so, if it becomes a second language people around the world won't be able to communicate

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

More schools should be connected to computers. → More information can be gathered from computers

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers?

Questioning which schools have computers.

THANK YOU

1. Reasons for choosing numbers 1 and 4 as the two best ways for improving Science in the North West are

4: To develop the North West community include all groups. Science teaching should benefit all groups. Some communities will benefit by addressing issues that can improve their living, other communities will benefit by computer aided instruction, internet-linking etc.

2. Reasons for choosing numbers 7 and 12 as the two least important recommendations for improving Science in the North West are

7: Although competition can foster Science interest, ~~the~~ teaching and learning should get first priority. Pupils who don't understand concepts or issues, loses interest.

12: Not viable. It will be very difficult to "maintain" the computers in the rural areas.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

15: It will not be fair only to do Science through the African culture. To keep up with the world, we'll also have to do Science through the Western culture

THANK YOU

1. Reasons for choosing numbers 14 and 9 as the two best ways for improving Science/Technology are nie lekker as jy opgewonde en goed voel oor dit wat jy gedoen het daarvoor Gee jou die geleendheid om meer kennis op te doen en meer gemotiveerd te word om beter te presteer in SKEI-Nat.

2. Reasons for choosing numbers 4 and 6 as the two least important recommendations for improving Science/Technology are Afrikaans is ons moedertaal en sal altyd daar bly en so wees. Hoekom moet ons bv. wetenskaplike name leer in Noord-Sotho, ek meen in ons daaglikse lewe is daar min wat dit kan praat. Rekonaar inligting is goed, maar nie almal van ons kan die inligting bekom nie.

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

Om nie net te konsentreer op rekonaar inligting en staat te maak nie, maar op dit wat jy kan anders en uitbeid. Probeer meer kinders trek.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

Nie van toepassing nie!

THANK YOU

1. Reasons for choosing numbers _____ and _____ as the two best ways for improving

Science in the North West are

Science is all about discovery, now
what better way, than for pupils to
actually find out on their own. This
arouses their interest and gives them
pride in what they do. As for technical
skills, they can't be overemphasized, as they
mechanize science

2. Reasons for choosing numbers _____ and _____ as the two least important

recommendations for improving Science in the North West are

Gender is irrelevant to science as
it tries to suggest that some one
sex is either inferior or limited than
another. Any person male or female can
discover and contribute equally to science. As

for "Africanisation of Science" it's a dividing force
to what science is trying to achieve i.e. agreement based on
facts.

3. What other suggestions can you give for improving Science in the North West?
Please give reasons for your answer.

Computer-based education should be
strived at for both rural and
urban schools. As the province advances
technological, science will become
more realistic to pupils; as they
will all get a hands-on experience.

THANK YOU

1. Reasons for choosing numbers 6 and 14 as the two best ways for improving Science/Technology are Science and technology are the basics and fundamental subjects in our everyday life. I therefore think that it would be to the best of everyone's interest to have these subjects being introduced to the marginalized majority in South Africa to uplift the standard of living of each and every South African. Secondly without venturing there's no discovery therefore no tangible knowledge
2. Reasons for choosing numbers 2 and 9 as the two least important recommendations for improving Science/Technology are Gender issues have been settled and we have a balance in all South Africa therefore we don't need to concentrate on the sexes. Secondly we live in a country that's undergoing a transformation process. One of those processes is the CURRICULUM 2005 which allows pupils to be more independent. Confining pupils therefore to a particular thing would be a dilemma.
3. What other suggestions can you give for improving Science/Technology? Please give reasons for your answer.
Making people aware of the fact that in our daily lives we make use of science/technology and live in. Simply waking up in the morning and switching on your kettle involves science
4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?
What the RDP hasn't included is concepts which will harness the fresh and creative mind of a youngster. This is a deprivation in itself. Pupils in the townships don't even have access to laboratories or a simple test-tube. and this should be looked in to - not by the Minister Sibusiso Bengu, but his delegates in the respective provinces.

THANK YOU

1. Reasons for choosing numbers 1 and 8 as the two best ways for improving Science/Technology are _____

1) People learn more when they can do things hands-on

2) When out of a classroom environment (teacher speaks while children speak sit) children become creative and learn more

2. Reasons for choosing numbers 9 and 5 as the two least important recommendations for improving Science/Technology are _____

9) If children have a choice to learn or not, most children would not want to learn, so they would not be educated.

5) English is (I think) the most important language. So, if it becomes a second language people around the world won't be able to communicate.

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

More schools should be connected to computers. → More information can be gathered from computers

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers?

Questioning which schools have computers.

THANK YOU

1. Reasons for choosing numbers 1 and 7 as the two best ways for improving Science/Technology are Introducing "real" life skills would mean that young scientists would gain more experience than they are now. It would build a spirit of adventure in each and every individual be that they are male and female. Gender issues should not be an issue in Science. Competition should also be introduced to make young scientist to learn to accept defeat or victory.

2. Reasons for choosing numbers 2 and 15 as the two least important recommendations for improving Science/Technology are looking at Gender issues while we are working with science will mean that there is no way forward. Africa is a third-world / Developing, so we will need empowerment from other advanced countries to become like them.

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.
Have a campaign on science and technology to make other young scientist aware of the advantages. Having done that now will be that in future Science / Technology will be advanced.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?
Funding has been the biggest neglect by RDP. If only RDP would also fund SCIENCE, (build science labs that are up to date) Biology, Biology labs as well. Promote health education at primary level.

THANK YOU

1. Reasons for choosing numbers 7 and 14 as the two best ways for improving Science/Technology are
1. Encouraging competitions in schools will make it possible for underprivileged children to get a chance in making projects and archiving something out of what they had made.
 2. If we share ideas of science amongst ourselves some young people may get something from what they have heard other people/pupils saying.

2. Reasons for choosing numbers 12 and 8 as the two least important recommendations for improving Science/Technology are
1. Many schools cannot afford to buy computers and that is a problem.

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

I suggest we as youth stand up to the government and demand more instruments to use in our Laboratories. so that we may be able to do some experiments so as to gain ^{more} information on what we are learning.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

I think the RDP should donate some money to schools and the schools will know what to do with the money e.g. buying computers and building libraries etc.

THANK YOU

1. Reasons for choosing numbers 7 and 11 as the two best ways for improving Science/Technology are because if there is more competitions and prizes, more people will enjoy and so it will develop. And scientists in South Africa must be asked what they think. You must listen to all the groups.

2. Reasons for choosing numbers 6 and 15 as the two least important recommendations for improving Science/Technology are Everybody in South Africa must be taught. You can't just concentrate on one group. Everybody must be taught. Science must be learned in the way it is learned across the world. Science must be taught so that people around the world would understand it.

3. What other suggestions can you give for improving Science/Technology? Please give reasons for your answer.
Concentrate on people a little bit older, like in old's house and up. The younger children must first be allowed to learn how to read and write and must be told there is something like science. Later on they can do science.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?
There must be workshops in the holidays where you can do experiments and play with science.

THANK YOU

1. Reasons for choosing numbers 8 and 13 as the two best ways for improving Science/Technology are Students should be allowed to discover the magic of Science and Science should not be forced on them
13 - South Africa is presently suffering a "brain drain" of human doctors?? The % of highly skilled people should increase for the development of any country and Science offers this. ✓
2. Reasons for choosing numbers 2 and 5 as the two least important recommendations for improving Science/Technology are Any country that relies on gender & language excuses is quipping itself a shot in the foot. Talent & Ability are more important than gender and language in technologically advancing countries like S.A. ✓
3. What other suggestions can you give for improving Science/Technology? Please give reasons for your answer.
In many parts of South Africa adequate teachers are not present for Science education so this rather be done than booting up disadvantaged communities in a later stage - English is the chosen medium of instruction so more emphasis should be placed on Learning Science in English for SA to compete as a technological force!!!
4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?
The RDP does not seem to understand that even though poverty is a concern, education is a bigger one for our growing population. A larger effort should be placed in the improvement of the education facilities than is presently shown. After all, what use is a rich country without the ability to implement it's wealth!!!

THANK YOU

1. Reasons for choosing numbers 7 and 11 as the two best ways for improving Science in the North West are

Competitions with more enterprise will encourage pupils to learn Science because pupils will participate if they get prizes. All interested people in North west for improvement of Science should be invited to improve Science.

2. Reasons for choosing numbers 2 and 3 as the two least important recommendations for improving Science in the North West are

This is the least because it will cause gender problems. Not only North west Science because the environment that should be learn about should be a broader area. Environment of the whole Country.

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

It should be improved because there are no equipments relevant to the subjects No laboratories. So if they improve Science they should build laboratories for practical investigations.

THANK YOU

1. Reasons for choosing numbers 8 and 10 as the two best ways for improving Science/Technology are because if you are the younger as scientist you have to think that what you suppose to do as you are younger. you have to create your own project so that you are making science and technology to succeed.
2. Reasons for choosing numbers 7 and 13 as the two least important recommendations for improving Science/Technology are without technology, science you want handle problem easily. you they can promote more career in schools special in primary in lower level and then then more about science that you can make your own object.
3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.
What we suppose to do is to go school by schools and recruit the students and make a challenge to all primary level and also in high school and then more about science and technology.
4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?
The RDP they did not give well because they tried by all means to recruit the student of south africa to create their own project and tell them what is all about science and technology.

THANK YOU

1. Reasons for choosing numbers 8 and 10 as the two best ways for improving

Science in the North West are

If you introduce Science as an interesting subject when children are in the primary they develop a creative attitude to Science when children learn Science by seeing and doing experiments as well as small projects their thinking capability develops and

2. Reasons for choosing numbers 2 and 5 as the two least important recommendations for improving Science in the North West are

this leads to future Scientists in Africa.

In today's world girls are considered equal to boys then why gender issues? If they learn to use scientific words in different languages when they attend tertiary institutions it will be difficult for them to cope. If they want to go out

3. What other suggestions can you give for improving Science in the North West? Please give reasons for your answer.

Science is not a subject which can be studied by just theory alone. Teachers can make it very interesting if they enable the students to do more creative projects like small experiments with things around them. When students do something

they feel proud of themselves and this leads them to do much more and hence

make South Africa have more

Scientists, Engineers and so on.

THANK YOU

- Reasons for choosing numbers 1 and 10 as the two best ways for improving Science/Technology are I think by starting in primary to give more ^{basic} science and technology will help the kids to know more about things like science fairs; when they are asked to do something for science fairs they would know what to do. We have different things that God gave us, some of us know things about science, some know cultural things they can do things with their own hands. Some have good hands in planting. So when real life skills are improved, every body will have something to do, to show that he/she can do it.
- Reasons for choosing numbers 2 and 5 as the two least important recommendations for improving Science/Technology are I do not think that being male or female should be taken seriously. You can be a female but do something that is normally done by boys. It does not matter if you are male or female as long as you can expose yourself with something you know is best. And again using our mother tongue is not that important when teaching science. We must use English because when speaking English that many people understand.
- What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

No I don't think I have a suggestion, I think everything that needs to be said is said.

- As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

For example at our school we have a small number of computers, we have to share one computer 3 pupils on one computer. Windows at other schools they are smashed esp. in primary school little kids catch flies from the wind coming inside of the window. Our school has not no Geography lab, no Mathematics Club and no Geography club. In fact there is only the English Club, Conservation, Environmental club.

THANK YOU

1. Reasons for choosing numbers 1 and 8 as the two best ways for improving Science/Technology are in 1. Many people didn't know certain skills until they started attending these expo competitions.
And in 8, As students are making their projects, collecting data from various people and various places, especially while doing a research project, you get to be educated, you get to be gain more knowledge than you had before entering for the expo competitions.

2. Reasons for choosing numbers 5 and 15 as the two least important recommendations for improving Science/Technology are because the info given on numbers mentioned above is false.
Expo doesn't help pay more attention to language issues in S.A.
Such expo doesn't help us to learn science through the african indigenous technology & culture and through the african world view of life and thought system.

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

I think all schools must be encouraged to enter the competition because there are some schools which do not enter this competition.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

With reference to computer, I think each and every school should contain computer subjects as there are many schools which do not contain computer subjects.

THANK YOU

1. Reasons for choosing numbers 7 and 13 as the two best ways for improving Science/Technology are 3. As daar meer interessante wetenskaplike kompeuses is vir die jongmense sal meer mense daarvoor belangstel. 4. As daar meer beroepe is waarvoor daar skoolkunde nodig is sal meer mense ook daarvoor belangstel en dit bevorder.

2. Reasons for choosing numbers 5 and 15 as the two least important recommendations for improving Science/Technology are

5* Giving more attention to language issues, en
15* Learning science through the African indigenous technology and culture, and through the African world view of life and thought system

3. What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

Die onderwysers kan dit op 'n meer praktiese manier aanbied. En dinge wat ons elke dag sien as voorbeelde te gebruik om ons die werk beter te laat verstaan. En daarvoor sal hulle ons aanmoedig om wetenskap verder te bevorder.

4. As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

Daar moet 'n kategorie wees vir Kuns en allerlei kunswerke.

THANK YOU

- Reasons for choosing numbers 1 and 10 as the two best ways for improving Science/Technology are Introducing more real life skills into science. technical and mixing so that people can be aware about our new technical methods
Giving Pupp pupils in Primary school in S.A much more basic science than presently. Children need to be taught more about science. They should do the fields of the science.
- Reasons for choosing numbers 13 and 15 as the two least important recommendations for improving Science/Technology are Concentrating more on environment issues I think I will help in the technology. The Earth particles have to do with geography that will help our new S.A. I don't think Africa technology is not good as far as I'm concerned I think the world technology will do better. We must forget about our culture a little bit.
- What other suggestions can you give for improving Science /Technology? Please give reasons for your answer.

I think we can improve science and technology. Teachers should do more science lessons and increase laboratories so that children can be able to do practical work. Sometimes it can be enjoyable. There must be more careers of science in S.A and more jobs.

- As a young scientist in 1997 what do you think the RDP has not sufficiently included with reference to Science/Biology/Geography/Computers, etc.?

I think it has not sufficiently included our computer system. In many schools in S.A computers are needed. The government must increase computers in Biology. There must be more apparatus and science so so that children can be able to do practical work.

THANK YOU