RESEARCH PORTFOLIO

Submitted by

Johnnie Wycliffe Frank Muwanga-Zake

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A Declaration

I declare that this research portfolio is my own work and that no part thereof has been submitted to any other university for a degree.

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JWF Muwanga-Zake

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I am indebted to my family, the MEd colleagues and the supervisors for the continuous encouragement, advise and patience.

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RESEARCH TOPIC 1

I DO NOT KNOW WHAT MY PROBLEM IS: IDENTIFYING SCIENCE TEACHER'S NEEDS

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ABSTRACT

A survey carried out during 1998 in rural schools of the South East Region (Butterworth) in the Eastern Cape Province revealed that science teachers do not seem to know their problems in teaching science. Teachers related their problems to lack of apparatus and laboratories. However, it appeared that lack of conceptual understanding of science and of practical skills prevented teachers from preparing practical approaches in the classrooms. Lack of conceptual understanding could have also been the cause of the teacher's inability to innovate and manipulate apparatus. The call for laboratories also seemed to be caused by lack of knowledge of what is done in a laboratory. Practical approaches to science seemed to be further undermined by the irrelevance of apparatus and science in a rural setting, where few community members and teachers might have never used apparatus or done practical exercises anywhere.

It is recommended that an integrated approach towards improving science education is required. That is, by means of workshops, all role-players in science education such as teacher training institutions such as Rhodes University, NGOs, the Department of Education and pre-service as well as in-service teachers, should discuss the problems in science education.

There is a need to supply basic apparatus and to make sure that in-service and pre-service courses emphasise skills in the use of apparatus, innovating apparatus and practical experiences, along with improving the teacher's conceptual understanding of science. A science college of education is highly recommended to enable a special focus on the plight of science education in the Eastern Cape Province.

It also felt that rural areas require special attention in terms of designing outcomes and learning experiences that bear relevance to that environment. The assumption that science education as perceived in industrialised areas can be beneficial everywhere is dangerous and gives science a bad name in rural areas.

The survey also showed that triangulation of research instruments is necessary to increase validity and reliability of any research programme. The most useful method appeared to be video recording the interviews.

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1. THE RESEARCH PROBLEM AND ITS CONTEXT

1.1 Introduction and literature review

A claim of knowing science is normally attached to attendance at a reputable institution with the most recent apparatus, laboratories and qualified teachers to enable science practice. This is because people, particularly in poor rural areas, normally practice and learn "textbook science" in academic institutions, such as schools and universities. In these institutions, science theories are verified or validated by use of approaches that are inevitably linked to apparatus with which many of its theories were discovered. The apparatus is unfortunately often foreign to many rural communities. In rural schools, approaches in teaching science and problems in those approaches are therefore expected to be mainly related to availability of apparatus and laboratories.

The author found many problems with practical approaches in science learning and teaching in rural institutions in South Africa, Lesotho and Uganda. Some of the main problems that were more prevalent in rural institutions were the availability of apparatus and laboratories that hindered practical approaches as prescribed in textbooks. Although goals of laboratory teaching can vary enormously (Berg & Giddings, Draft manuscript) and, according to White (1996:761), the purposes for laboratories is not universally agreed, a survey by the Centre for the Advancement of Science and Mathematics Education (CASME) (1992:35) showed that teachers in South Africa agreed that practical approaches were basic requirements towards understanding science.

According to Hodson (1996:755), the purposes that teachers assign to practical work may shift over the years. This shift may be due to developments in science and technology and in a change in a teacher's conceptual understanding of science over the years. Since scientific and technological developments do not reach all communities at the same time, Hodson's view seems to apply equally to shifts over space, particularly in countries like South Africa. Among other factors that affect science practice in the classroom, huge differences in problems and needs, availability of qualified teachers, academic standards or science literacy levels, cultural differences and economic standards between South African communities may require different approaches and cause different problems in teaching science.

For example, in 1983 when the author started to teach at Lamplough High School that is found in a rural area of the South East Region, teachers used the laboratory as a store. Teachers believed that science could not be practised in such a laboratory that had no tap water and electricity. Many other rural schools seemed to experience similar problems and held beliefs about laboratories similar to those of teachers at Lamplough High School. Such problems undermined the use of laboratory approaches that teachers could use in science. On the other hand, during the same period, at Stirling High School in an East London suburb where there were many well equipped laboratories and more qualified and experienced teachers, the author's children claimed to have enjoyed many practical experiences in science classrooms. Matric science results at Stirling High School were often better than those at Lamplough High School.

Continuous investigations are necessary to check whether teachers are keeping abreast with scientific and technological developments and approaches in the classroom. It is also important that approaches and problems are investigated before Outcomes-Based Education (OBE) is designed and implemented. The current approaches in teaching science and problems faced by science teachers will influence the success of Natural Sciences in the OBE curriculum.

1.2 Survey area

This survey was carried out in the Easter Cape Province, in an area known to the Department of Education as the South East Region (Figure 1). Administratively though, the sampled area fell under Butterworth District. (The administrative area was not exactly the same as the educational area). This area lies approximately between 27 and 30 East, and between 30 and 33 South (Swanevelder *et al*, 1975). It is approximately 110 kilometres by road from Umtata on its Eastern side, approximately 106 kilometres by road from East London on its South Western side and approximately 150 kilometres by road from Queenstown on its North Western side. It is about 60 kilometres by road from the Indian Ocean.

Most of the South East Region is rural. The majority of people seem to be peasants that own livestock such as cattle and sheep, and/or cultivated maize. A large proportion of people in the surveyed area did not seem to have formal jobs that earn steady incomes.

Figure 1 Survey Area

Therefore, not many people seemed to be able to contribute financially to schools. With the exception of two schools in Butterworth Town, the government fully funded the rest of the schools in the region.

Furthermore, schools outside Butterworth Town comprised of Black learners, specifically of the Xhosa tribe. Expatriate staff mainly from India, Sri Lanka, Uganda and Ghana is often found to be teaching science in the high schools. However, junior and primary schools appear to be totally staffed by South African Black teachers. The schools that were sampled were owned and funded by the government and only Black South African science teachers took part in this research. This is because this research initially focussed on junior schools and the only high school that was sampled had all its three science teachers Black.

The schools in the sampled area were either primary (Grade 1-6), junior (Grade 7-9) or senior (Grade 10-12). This was based upon the old Transkei system of schooling. The author was a teacher for 11 years between 1983 and 1994 at Lamplough High School at Mission Location, which is found in the survey area.

1.3 The research problem and its context

The author taught Physical Science and/or Biology in two institutions in the rural part of the sampled area. His teaching included Physical Science and Biology in Standards 8, 9 & 10 at Lamplough High School - Butterworth (1983 - 1994) and Biology and Biology methods, part-time, at Bethel College - Butterworth (1990-1991). From that teaching experience and visits to other schools in the area, the author found a wide range of problems that hindered recommended approaches to science teaching. For example, much of the required apparatus was not available and some of the apparatus was not in working order. Other problems that compromised classroom science practice emanated from over-crowding and lack of time to cover a very long syllabus that the Department of Education insisted had to be completed in pre-determined periods. Therefore, the author could not provide all the prescribed practical experiences to learners and learners had to memorise a large proportion of the science syllabus, particularly for examination purposes.

On the other hand, the author found that there were possibilities for practical approaches in township schools that were not available in rural schools. For example, the author could carry out some of the practical work at Masonwabe Finishing School at Duncan Village Township in East London where he taught Physical Science and Biology from 1994 up to 1996. This was because Masonwabe Finishing School was neighbouring to schools and institutions that had well equipped laboratories. The author could occasionally borrow some apparatus and audio-visual equipment from neighbouring schools, which was not possible at Lamplough High School and Bethel College.

Problems experienced by the author at Lamplough High School were similar to some of those listed by MacDonald & Rogan (1988:234) in the former Ciskei. MacDonald & Rogan also included poor resources and impoverished communities that could not contribute towards the curriculum. Although MacDonald & Rogan included inadequate teacher training, the author considered himself and other teachers to have more than the recommended or required "paper" qualifications to teach science in secondary schools. Hofmeyer (1993), reported in Bhika (1996:66), indicated that there was no correlation between the qualification of teachers and pupil performance. However Bhika opposed that view by saying that the importance of having the necessary qualifications to teach could not be ignored. In support of Hofmeyer, there were reports in many South African newspapers and television discussions that claimed that highly performing Matric schools did not necessarily have highly qualified teachers.

During workshops run by the Centre for the Advancement of Science and Mathematics Education (CASME) at Butterworth and in sessions for the Further Diploma in Education (Science Education) (FDE Science Education) at Rhodes University during 1998, teachers, including 'qualified' teachers, claimed that they have never done much of the prescribed science practical work. Again these teachers were trained in rural teacher colleges such as Butterworth Teacher College and Lumko Teacher College. It is common to find teachers who had stayed in the rural areas during their schooling and teacher training - perhaps such teachers would be more qualified to deal with the unique problems in rural areas and are a good source of data on the science problems and approaches in rural areas. These teachers claimed that they, and some of their students, obtained very good science grades at Matric. This implied that Matric science in South African schools could be taught and be passed by the use of theoretical approaches and that some teachers obtained their teaching diplomas without practical work in science.

It is thus possible that many science teachers in South Africa, particularly in rural Black schools, have had little or no practical science experiences at school and in tertiary teacher training institutions. Hence, it is likely that teachers rarely practice science with learners in those schools. Teachers that have never had practical science experiences may find problems in teaching science because they are likely to hold misconceptions in science and science methods, and may therefore use wrong approaches towards teaching science. Such teachers may also fear to attempt experiments in class. Lack of skills in performing experiments can lead to authoritarian approaches, such as chalk-and-talk methods, even where apparatus and a laboratory are available.

Follow-up visits after CASME workshops to some schools in the South East (Butterworth) Region during 1997 revealed that many teachers had the required basic science apparatus. Apparatus was often found dusty or packed in containers in which it was bought. Some teachers did not even know the names of some of the equipment or were not aware of what was in their laboratories. Other teachers said they were not keen to touch some equipment for fear of damaging the equipment or being injured, and so could not allow the learners to touch equipment. Teachers also expressed fears from experiences of experiments that did not work as described in textbooks - ‘the black box syndrome’ (Nott, 1996). For example, the author has experienced cases where attempts in science practical work ended up in descriptions of procedures. Food tests for instance, are often described to students, and not carried out practically partly because it is rare to obtain the colours described in textbooks. Other schools had laboratories in which teachers had never performed experiments.

There is currently much interest in science curriculum reforms in South Africa. According to Robottom (1992) reported in Robottom & Hart (1993:591) the argument behind these calls in other countries appears to rest on the belief that a greater number of science graduates will result in amore skilled and therefore more productive work-force, which in turn will contribute to an internationally more competitive nation (the 'clever country') and redress some of the country's balance of trade problems. Similar calls were made in South Africa, for example to justify the introduction of OBE. It is in the same light that South Africa declared 1998 the Year of Science and Technology. The change towards the OBE in South Africa, however, ought to be preceded by an investigation in the approaches and problems of teachers. For example, in Natural Sciences, it is required that science teachers prepare hands-on experiences for their learners. The Natural Sciences Report of the

Technical Committee and Support Team (Pretoria, March 1997:8) stated that Specific Outcome 1 requires the learner to use process skills to investigate phenomena related to the Natural Sciences. Processes of investigation encompass skills such as questioning, observing, hypothesising, predicting, the collection, recording, analysis, evaluation and interpretation of data, and the communication of findings and/or conclusions that may be done individually or in groups. Hence, OBE requires apparatus and a clear understanding of the use of practical laboratory approaches.

The broad aim of this research was to investigate the approaches and problems faced by science teachers in rural areas of the Eastern Cape Province. This investigation was motivated and justified by the author's experiences described above and from literature, both of which indicated that there were serious problems that may hinder practical approaches to science. A survey was used in this investigation.

According to Cohen & Manion (1994:83), surveys gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events. A survey was seen as the cheapest way of obtaining a wide range of data about approaches and problems from the widest proportion of science teachers.

Although this survey may not lead to generalisable conclusions and recommendations, data obtained can be used to plan a more extensive and detailed survey. Research procedures tried in this research may be improved upon and be used to obtain data about approaches and problems in teaching science in rural schools. Further research would ultimately lead to recommendations towards improving approaches in science teaching and to better strategies of implementing OBE in rural schools. Results will also help in designing a better curriculum for training science teachers and for in-service programmes.

The South East Region, and most of the Eastern Cape Province, is largely a rural environment. Findings from this survey are therefore likely to be relevant to the majority of the Eastern Cape schools. Appendix IX shows that a high proportion (42%) of out-of-school youth lived their childhood in rural homes (as compared to 28% urban and 30%

metro) in the Eastern Cape Province. It is important that in science education, a great deal of attention is paid to rural areas.

1.4 Specific research questions

1. What do teachers in the South East Region of the Eastern Cape Province perceive as problems in teaching science?

2. What approaches do science teachers in the South East Region use in science lessons?

3. What are the implications of problems and approaches of science teachers in the South East Region to OBE?

2. METHODS

2.1 Research paradigm

The choices of the research paradigms described below were based upon the author's desire to involve teachers as active participants in this research and in their subsequent development into reflective science teachers and researchers. One of the objectives of this research was to initiate a process by which science teachers are able to accurately identify their science teaching problems, improve upon their approaches and be able to solve some of their problems in science classrooms. The option of using action research was entertained. However, it appeared that it was important to survey the approaches and problems of the teachers prior to action research. The survey employed a questionnaire, interviews, the Science Teaching Observation Schedule (STOS) and video recording. Action research may be adequately used after this survey.

According to Robottom & Hart (1993:596) an interpretative or critical approach incorporating a constructivist epistemology will enable different questions to be addressed and different solutions to be obtained. They continue that it is anticipated that the answers to such questions will be more readily accessible to teachers and others involved in science curriculum reform. Thus the research ought to have the potential to influence practice. Kuiper (1997) believes that a move towards research approach where the actions, ideas, thoughts, priorities, problems and so on, of people in education are described in a predominantly qualitative way, with serious consideration of context is necessary. Kuiper (1997) also believes that in order to generate viable and useful qualitative data, new methods that rest largely on social critical theory and post-modern notions of knowledge should be appropriate to the social setting in which education takes place. For this objective to be realised, the teachers and learners have to be approached as responsible and independently thinking individuals (Kuiper 1997).

Although it is widely believed that there is no agreed upon definition of post-modernism, the various views above were mainly considered to be adequate in describing post-modernism as well as the objectives and methods of this survey. A need for a post-modern research approach was well articulated by Kuiper (1995:27) who believes that post-modern thinking has had a growing influence upon education since 1960s mostly as a critique of western society. One context in which western traditions require critical analyses and investigation is in the science classrooms of rural schools of the Eastern Cape Province.

Kuiper (1995:28) continued thus there is a move to individuality and individual thinking beliefs and preferences. Kuiper's view on individualism can be extended to the individuality of a rural context, where science as a western construct is taught without the traditional philosophies and equipment of the western culture, and to individual teachers whose culture may be contradicted by the western culture, particularly by the science methodology - Kuiper's view can thus be interpreted as consequently recommending interpretativism and social constructivism in research. Thus there seems to be a strong link between post-modernism, interpretativism and social constructivism, all of which have been employed in this research.

This survey was post-modern, in planning, execution and interpretation. Planning was a team debate involving other MEd. candidates, their supervisors and the sample of teachers that participated in the survey all of whom tried to develop the ideas put forward by the author on the basis of their individual experiences, knowledge and expectations. The execution of the survey was post-modern because participants were not restricted in their responses, participants contributed to the final logistics and planning of the survey, and the survey was not structured upon traditional empirical and positivist research designs that participants had to adhere to.

The advantage of the post-modernism approach in this survey was that teachers had an opportunity to critique the status quo of their schools and the contemporary science education methods. To achieve this critique, questions in the questionnaire and interview were open-ended to cater for a variety of responses. Post-modernism also shifted the survey away from the traditional 'correct' research procedures, allowing for new partnerships between researcher and the researched thus making the research applicable in a rural context. Furthermore, many of the video records were impromptu but within periods of time that teachers agreed were acceptable and convenient to them. No prescribed ‘correct’ science teaching approaches were defined for teachers such that the problems were not defined either - teachers were instead given an opportunity to explore the applicability and effectiveness of their approaches. The teachers were also given an opportunity to suggest possible solutions to their problems that could possibly improve their approaches to science teaching.

The survey was post-modern in the interpretation of findings because approaches and problems of individual teachers, as well as the researcher's personal accounts of the research process were taken seriously even if such problems and approaches could not have been frequent among other teachers in the sample. Such individual approaches and problems were the realities that were happening in science classes and so had to be taken seriously.

Consequently this survey was inevitably interpretative (largely subjective) because post-modernism, interpretativism and social constructivism seem to be so much linked that the three go together. The methodology in this survey used also fitted the Australian Science Teachers Association's (ASTA) (1995:A1.10) view that interpretative paradigms reject the idea that scientists study phenomena without being prejudiced or influenced by prior ideas, values and feelings.

For example, the survey was motivated by the author's experiences and opinions, and the fact that these influenced the research process, the results and the interpretation of those results, was acknowledged. Furthermore the research design was largely a negotiated product of the author's and the teacher's opinions on how best approaches and problems of science teachers could be obtained. Teachers' participation included a workshop during which teachers were able to ask questions about the research and its relevance to their practice, and to learn some aspects of educational research. The procedures were also deemed fair to teachers since teachers agreed upon those procedures. It was also interpretative because the survey sought the classroom problems and approaches as perceived and interpreted by each teacher. Such views of each individual teacher were considered to be largely subjective because they could have arisen out of individual and unique experiences; experiences which each individual teacher may have interpreted differently. Therefore, it was important that respondents were unrestricted by the research instruments to express personal perceptions of problems and approaches in the way they taught science.

The designing process of the survey was social constructivist. While the author initiated the survey, other people participated in the final design. For example, teachers contributed towards planning the school visits and in sequencing or grouping items in the questionnaire. Social constructivism was also experienced during the forums during which MEd.

supervisors and candidates contributed ideas towards the survey process. The survey itself was a social phenomenon because it was a social interaction between the author and other participants including the sample of teachers.

It was deemed necessary to use questionnaires and interviews as instruments of post-modernism, interpretativism and social constructivism. Kuiper (1997) classified questionnaires among interpretative methods and interviews among post-modern methods. For example, interviews were informal discussions during which teachers gave direction to the interview.

2.2 Assumptions and presuppositions underlying this research

It was assumed that all participants were qualified teachers with at least a Primary Teacher's Diploma (PTD) and that they understood English, particularly as it is used in the science that they taught, and in questionnaires and interviews. Teachers were expected to have knowledge of the whole syllabus that they were expected to teach and to be aware of the practical work that is involved in each topic. It was also assumed that teachers were willing to share truthfully their approaches and problems in science teaching, through questionnaire, video recorded interviews and class visits.

The South East Region was assumed to be a representative of rural conditions in the Eastern Cape Province and so to have teachers that use certain approaches that are characteristic of rural schools. Rural schools were presumed to experience unique problems in teaching science that differed from problems in urban schools. These assumptions were based upon the author's experiences and observations. For example, many schools did not have electricity such that they could not use electrically operated equipment like the Van der Graaf Generator.

2.3 Instruments

2.3.1 Questionnaire

The questionnaire that was used is presented in Appendix I. Advantages of questionnaires are discussed well in Cohen & Manion (1989). Advantages that were realised in using questionnaires in this survey were that a wide range of topics was covered and respondents answered questionnaires at their convenient times.

2.3.2 Science Teaching Observation Schedule (STOS)

As a way of triangulation of certain aspects of the questionnaire, classroom approaches and problems were further investigated by the use of STOS, also known as instantaneous sampling, presented in Appendix III, on the same group of teachers to whom questionnaires were applied. This is a modification STOS in Appendix II that was used by Kuiper (Kuiper's PhD. Thesis, 1991:107).

According to MacDonald & Rogan (1988:226), the STOS was developed in the early 1970's for use in the evaluation of Nuffield science materials in England. Since then, STOS is reported to have been used by MacDonald & Rogan (1988), Hacker et al. (1979), Dreyfus & Eggleston (1979), Keiny & Jungwirth (1982) and Hinton (1985) (MacDonald & Rogan, 1988:226).

The STOS schedule was chosen because STOS facilitated the recording of science processes such as observing, speculating, problem solving, designing experiments, interaction and teacher or student activity. The activities listed on STOS were recorded over a time-unit of one minute. This is in support of MacDonald & Rogan's (1988:229) view that few transactions were lengthy and Kuiper's (PhD Thesis) view that a one-minute time interval allows more accurate estimate of the frequency with which the observed activities occurred.

2.3.3 Video recording of class visits and of interviews with teachers

Further triangulation of questionnaires and STOS was done by class visits and interviews with teachers that were video recorded. Discourse analysis was used to make sense of the video-recorded interviews. One workshop was also video recorded to capture spoken and other forms of communication. Video recording was done with prior consent of teachers and students. Teachers and students were notified of the commencement of video recording.

Chantler (1996:99) pointed out that video-taped material of lessons can be used to critically analyse teaching, keep a record of the reality and allow a revisit of that reality for further reflection and interpretation of factors. The video record could capture some part of reality that may have been missed in the STOS. Furthermore, the video records highlighted the influence of the researcher on the research process.

2.3.3.1 Class visit

It was only possible to video record one teacher delivering a lesson on electricity because other teachers were continuously involved in SADTU meetings. The lesson was about electricity for Standard 7 learners.

2.3.3.2 Interviews

A non-directive interview as described by Euvrard (1997:3) was used. That is, the author probed the interviewee, with no set questions. The sequence of questions was determined by the answers that were given by the interviewee. Hence, the responses were unstructured, in a manner similar to the description of unstructured responses by Euvrard (1997:6), because respondents answered in any way they chose. The interview mainly led teachers to comment on their problems in science classrooms.

2.3.3.3 Discourse Analysis

Cohen & Manion (1989:253) defined discourse analysis as an examination of ‘accounts as they occur in context’. Michael Foucault (1970:52) reported in Mpahlele (1996:239) described discourse as ‘any structure of knowledge which determines the way in which the world is experienced and seen. This structure of knowledge is selected, organised and controlled by certain procedures. Foucault further said that a discourse is both an instrument of power and a potential starting point for an opposing strategy, because discourse is constituted by the desire to be ‘unrestricted’ and an institution’s desire to constrain and control it.

In this survey discourse revealed the power relations between the author and the teachers that attend the author's workshops, as well as between teachers and their learners in the classroom. Discourse was studied by discourse analysis. Discourse analysis was done by playing the videotape repeatedly. Discourse analysis was also used to validate the findings from STOS.

2.4 Research sample and sample size

The sample comprised of science teachers in 10 junior and 1 senior secondary rural schools of the South East Region (Butterworth District) in the Eastern Cape Province. These schools were geographically accessible to each other. The distance between such schools was such that teachers could reach each other easily. Since the author wished to work with the teachers in the sample towards improving their approaches and solve some of their problems, and in subsequent research programmes, the proximity between teachers could enhance co-operation between themselves and between them and the author. That proximity may also ease the gathering of participants for discussing the findings from the survey with the author. The proximity made it easy for the author to reach all participants easily in a short time.

A low return rate of questionnaires led the author to apply an additional questionnaire to FDE Science Education candidates at Rhodes University - East London Campus. With the exception of one who taught in a Mdantsane Township school, the rest taught in rural schools in the Eastern Cape Province. Therefore, the sample of teachers remained largely rural.

2.5 Research Procedure

An application for permission to carry out this research was made to the Permanent Secretary, Department of Education in the Eastern Cape Province, although permission was obtained by verbal communication after the author visited the office of the Permanent Secretary. The research was also discussed with the Director of CASME, where the author is employed. Thereafter Subject Advisers were approached and identified the teachers that took part in this research.

A pilot survey to test the adequacy of the survey instruments was conducted. This was followed by a forum involving the MEd supervisors and candidates at Rhodes University, Grahamstown. A main survey followed which comprised of;

- a research workshop with the sample of science teachers
- travelling to each of the schools to collect questionnaire and to video record the interviews and science lessons.

2.6 Sampling programme

2.6.1 Pilot survey

Pilot sampling took place in the first school term of 1998. This involved the administration of the questionnaire to two teachers and visiting one science lesson in one of the selected schools.

Pilot sampling was followed by reviews and critical analyses of pilot findings in a forum by the supervisors and candidates of the M.Ed. course at Rhodes University, Grahamstown. During that forum, the STOS in Appendix II was modified to that in Appendix III to enable the recording of the sequence of events apart from the recording the activities in the science classroom.

2.6.2 The main survey

2.6.2.1 The workshop

The forum above at Rhodes University was followed by a one day research workshop which took place during the second school term. This workshop was introduced to teachers as a preparation for a research project that is aimed at surveying their approaches and problems in teaching science. Research in education was also discussed with the teachers, mentioning its advantages and actors. The survey procedures were discussed with participating teachers during the research workshop and its relevance to the teacher's practice was debated. Further planning and changes in the survey were done with teachers during the research workshop to make it as fair as possible to the teachers. Consent to do research with each one of them was obtained verbally during the workshop. Teachers also advised the author when he could visit their schools for class visits and interviews.

The author read through the questionnaire with the teachers to make sure that a common understanding of the items in the questionnaire was achieved. Most of the questionnaires were handed out to teachers during the research workshop. However, 8 of the 12 teachers opted to complete their questionnaire at their convenient time, 3 teachers having completed and returned questionnaire during the workshop. (1 teacher completed questionnaire during an FDE session).

2.6.2.2 School visits

Science classes were visited and a lesson as well as interviews with some learners were video recorded. The STOS was applied during the lesson. Teachers and learners were interviewed for problems they encountered in teaching and learning science respectively. The learner's record or exercise books were also checked during the class visit to check whether some of the information supplied by the teacher in the questionnaire agreed with the learner's records of work.

3 RESULTS

All schools that were visited had no electricity or tap water. One school was housed in small huts without windows. Three of the schools had rooms designed to be laboratories but they were not being used as such. There was no evidence of use of apparatus where apparatus was found.

One of the schools had closed before midday whilst many others started classroom instruction late. All schools appeared to have lengthy breaks that commenced as early as 9.30 a.m. and lasted as long as an hour and a half. Thus it appeared that learning activities in these schools were less inspected and achieved much less learning time than expected.

3.1 Answers to questionnaires to science teachers

2nd Quarter of 1998.
12 teachers responded from 10 schools.
Grade 5-9 = 5 teachers
Grade 10-12 = 7 teachers
All teachers were from rural areas, except one from a township school.

Part A. Practical work that teachers can do at school

Note: The numbers in the table below represent the number of times that a response appeared teachers - it does not unfortunately indicate the combination of answers that each teacher gave.

1 Topics that teachers had taught by the second school quarter

	Grade 5-9	Grade 10-12
Electricity	5	3
Pressure	3	-
Electrostatics	2	1
Work, Energy & Power	2	2
Atomic structure/ periodicity/bonding	2	2
Flowering plants	2	-
Light	2	1
Density	1	-
Salts	1	-
Soil	1	-
Motion, Momentum & Vectors	-	5
Waves	-	2
Phases of matter	-	2
Sulphur & compounds	-	1
Acids & Bases	-	1

2. Topics for which teachers have used experiments/practicals?

	Grade 5-9	Grade 10-12
Electricity	3	3
Force	***2***	-
Electrostatics	2	-
Light	2	-
Pressure	2	-
Chemical Reactions	1	2
Density	1	-
Measurement	1	-
Combustion	1	-
Sulphur & compounds	-	1

Motion, Momentum & Vectors	-	3
No experiments	-	3

3. Other topics for which teachers hope to use practicals later

	Grade 5-9	Grade 10-12
Light	3	1
Reactions with Oxygen, Hydrogen and Carbon Dioxide	3	1
Energy, Work & Power	2	1
Acids & Bases	1	1
Electricity	1	1
Chemical Reactions	1	-
Le Chatelier's Principle	-	2
Rates of reactions	-	1
Sound	-	1
Momentum	-	1
Cells	-	1
None	-	2

4. The reasons why it is not possible to organise practical work for some topics

	Grade 5-9	Grade 10-12
Lack of apparatus	4	6
Lack of knowledge to organise practical work	1	1
Not enough time	-	1

<u>Part B The procedure of conducting practical work</u>

1. Learners start and conduct practical work by themselves

	Grade 5-9	Grade 10-12
Sometimes	3	1
No	2	1
Yes	2	4
Not applicable because of lack of apparatus	-	1

2. Learners allowed making predictions

	Grade 5-9	Grade 10-12
Yes	4	5
Sometimes	1	-
No	-	1

3. Learners allowed supporting their predictions

	Grade 5-9	Grade 10-12
Yes	6	4
No	-	1

4. Learners told what they are supposed to see

	Grade 5-9	Grade 10-12
No	4	4
Sometimes	2	2
Yes	1	-

5. Skills that teachers think learners acquire from practical work

	Grade 5- 9	Grade 10-12
Observation	5	4
Listening	2	2
Self-discovery?	2	-
Sharing & co-operating with others	2	-
Creativity	1	-
Investigation	1	-
Handling of apparatus	1	-
Drawing of conclusions	1	2
Discussion	1	-
Reasoning & ***cognition?*** & thinking	-	5
Data analysis	-	2

Understanding?	-	2
Experimenting	-	1
Appreciation of nature	-	1
Decision making	-	1
Organisation of data	-	1
Management skills	-	1
Communication	-	1
Questioning	-	1

6. Whether planned skills are acquired

	Grade 5-9	**Grade 10-12**
Yes	3	2
Sometimes	3	2
To some extent	-	1

7. Whether teachers demonstrate to learners what they are supposed to do

	Grade 5-9	**Grade 10-12**
Yes	3	-
Sometimes	2	3
Partly	1	-
No	-	2

8. Science skills that teachers think they test for in learners

	Grade 5-9	**Grade 10-12**
Observation	4	3
Creativity	2	1
Drawing Conclusions	-	2
Following instructions	1	1
Thinking	1	1
Investigating	1	-
Decision Making	-	1
Experimentation	-	1
Interpreting Results	-	1
Handling Apparatus	-	1
Management	-	1
Understanding	-	1
Critical Analysis	-	1
Insight	-	1

9. Whether experiments always work

	Grade 5-9	**Grade 10-12**
No	4	1
Yes	1	1
Sometimes	1	1
If tried before the lesson	1	-
Often	-	1
Not applicable	-	1

10. Experiments that have worked well

	Grade 5-9	**Grade 10-12**
Electricity	4	2
Acids &bases	1	2
All	1	1
Light	1	-
Preparation of Oxygen	1	-
Density	1	-
Measurement	1	-
Cells	-	2
Momentum	-	1
Preparation of Hydrogen Sulphide	-	1
Metals + Water	-	1
Inorganic Chemistry	-	1

11. What could have made such experiments to work easily?

	Grade 5-9	**Grade 10-12**
Availability of apparatus	3	1
Prior practice & experience	2	2

Simple experiments	1	2
Favourable conditions	-	1

12. Experiments that do not work easily

	Grade 5-9	Grade 10-12
Static electricity	3	2
Chemistry	2	-
Pressure	1	-
Biology	1	-
Salt formation	1	-
Mixtures & Compounds	1	-
Electricity	-	2
Ticker-timer	-	1
Gas experiments	-	1

13. What could make such experiments difficult?

	Grade 5-9	Grade 10-12
Scarcity of apparatus	5	3
Handling of apparatus	1	1
Unfavourable conditions	1	1
Humidity	-	1
Lack of skills	-	1

14 What do you do with the results that learners obtain?

	Grade 5-9	Grade 10-12
Record	2	1
Explain problems?	1	1
Compare with expected	1	1
Application	1	-
Learners make conclusions	-	1
Analyse	-	1
Discuss	-	1

15 What is done if an experiment does not lead to expected results.

	Grade 5-9	Grade 10-12
Try again	4	2
Discuss why	2	1
Stick to the textbook	1	-
Tell them the truth/expected	1	1

16 What do you do if one student or one group gets different results?

	Grade 5-9	Grade 10-12
Correct them	3	-
Identify possible causes	2	2
Repeat experiment	2	-
Negotiate for consensus	-	1
See how they did the experiment	-	1

Part C Teacher's opinions about CASME workshops

1. What have you found useful in this workshop?

	Grade 5-9	Grade 10-12
Group work	1	1
New knowledge	1	2
Explanation of problems	1	-
Handling of apparatus	1	-
Not to take things for granted	1	-
Refreshing	1	-
Insight	-	1

2. Is it possible for you to apply the knowledge that you have gained in the workshop?

All teachers said they could apply the knowledge gained in the workshops.

3. What will make it possible for you to apply this knowledge?

	Grade 5-9	Grade 10-12
Handouts	2	1
Availability of equipment	1	2
Knowledge	1	1
Sharing with learners	1	-
Applicable in everyday life	1	-
Acceptance of change	-	1
Easy	-	1

4. What will make it impossible for you to apply this knowledge?

	Grade 5-9	Grade 10-12
Insufficient apparatus	3	3
Resistance against change	-	1
Lack of creativity	-	1
Lack of commitment from students	-	1

5 What do you want CASME to add to the current workshops?

	Grade 5-9	Grade 10-12
Supply equipment	2	-
How to conduct experiments	1	1
More workshops	1	1
More time	1	-
Invite more people	-	1

3.2 Teacher qualification

Six teachers supplied their qualifications with the questionnaire:

PTC (No training in science)	1 teacher
Diploma in Education (Science & Mathematics)	1 teacher
B. Com. (No training in science)	2 teacher
HED (Science & Mathematics)	1 teacher
STD (subjects not stated)	1 teacher

This sample converts to 50% of teachers with no science training.

3.3 Results from school visits

There were many activities that involved teachers during the second and third school quarters of 1998. It was the period during which teacher unions threatened the government with strikes. At the same time, OBE and Parent Teacher Student Associations (PTSA) were being introduced. There were also choir and athletics school competitions.

Therefore many class visits did not materialise as teachers were often absent to attend either of those activities and some of the appointments with teachers at their schools failed. The researcher then resorted to randomly visiting these schools and carrying out the research where it was possible. This strategy obtained one lesson in which STOS and video recording were applied and two video-recorded interviews. The strategy had the advantage of observing the 'real' situations at these schools since teachers would have no opportunity to prepare for the researcher's visit. However, the strategy cost more time and money.

3.3.1 Video recorded interviews with science teachers

The author's statements are written in Italics. Because of the length of the records, only statements that are considered to be related to approaches and problems in teaching science are transcribed below.

3.3.1.1 First Interview with science teachers (3), a principal and students (School A)

Anything to say about science education?

Male Teacher A

Truly speaking, I have been a science teacher for almost 18 19 years. I love science and I like it very much and it is a …… most part of …. But the problem is …. With the current situation in our schools as you can actually see the very laboratory, which is just there by virtue of the walls without much of an activity that actually takes place. We have a problem of equipment, problem of actually making science to actually be studied as science. That means involving the perspective of it, which really makes it more interesting and more easy in understanding for students. Now I presented science up to 1995 and last year that I really presented it within science department and after I left for the commerce stream. The actual problem which really made me to leave science teaching out of …. I mean, bearing in mind that as I said, in presenting … is the question of equipment. Since the burning of the school in 1993. Now 94/95 I was really having a problem of a practical approach to teaching science because the laboratory is to a staff room and the very chemical section as you can see it is an office. So that means now every chance of doing a practical is rather squeezed out of the teaching situation. And therefore from that perspective telling science to students becomes very unscientific as against really having a practical approach. I said now after 1995 I decided to resign from the science teaching and go straight for economic science. Not that really I do not have any love for science. It is still number one subject in all my sort of curricula of subjects and so on. But the approach which is highly hundred per cent a theory without any practical perspective possible has made me resign science teaching that only this year now I had to come back to science teaching to rescue the standard tens for the sake of no teacher is sort of readily available from the Department of Science and so on. And of course since I still love science, I have easily …. But as I say teaching all in the theory is still a handicap, which I am not prepared to sustain for a long period of time. I mean I am just helping this year hoping possibly that next year somebody will be coming up. Now with the current perspective that we are about to receive electrification of this sort of community and so on from sort of ESCOM, then it is likely that, that will sort of begin improvement in the sort of a science teaching because really even in the past, even though we did have a laboratory with some little equipment the problem of electricity has always been handicapping a lot of scientific approach to … I mean practical demonstrations and experimentation. As I say now at least with the future view of the laboratory being itself available and the school having been sort of electrified then there is my prospect of myself coming back to the science teaching as a science teacher and not somebody to tell science to students.

Okay, so this is supposed to be the store.

Male Teacher A

This is supposed to be a storeroom for chemicals as you can actually see. But as you can see now …. Such that we do not have the labelling now …. Chemicals of a specific type and so on. There is no more that order. Even when you look for a chemical right now - you used to place it here but it is no more there. Something else is now accommodated there. So it is no more a working laboratory as such. Such that even demonstrations in class for instance, you have to spend time trying to locate the equipment. Where is it? It used to be here and so on. Hence now it is very much deranging to teach science under such conditions really.

Ladies, do you have any addition to that? What do you see as problems that you are facing trying to teach science here?

Lady Teacher B

Actually what Mr Ngoma has said - it is really true. Because we are encountering problems in teaching this. As you can see - look at that Van der Graaf generator there. We cannot operate it because of electricity as he has already stated. It is like a toy to us.

So it is the absence of electricity……..

Lady Teacher B

Yeah as he has already stated because it is a problem really. And we are encountering problems like you are teaching many students. I have many students in standard 8A. They are about sixty something… 64/65. Somewhere there. So when it comes to the practical side of the subject, you have to make them touch the apparatus. But using one kit, it is not possible.

Yeah?. Even if you try group work?

Lady Teacher B

Yeah. And by the time you are teaching this group, other people are not concentrating. They are making noise. They are doing their own things because they are not doing anything. And they should learn to feel and touch the apparatus and to observe themselves and do the thing themselves.

So for that kind of stream. The actual problem which really made me to leave science teaching out of. I mean bearing in mind that I said, in presenting is the question of equipment. Since the burning of the school in 1993. Now 94/95. I was really having a problem of a practical approach to teaching science because the laboratory is to a staff room and the very chemical section as you can see it is an office. So that means now every chance of doing a practical is rather squeezed out of the teaching situation. And therefore from that perspective telling science to students becomes very unscientific as against really having a practical approach. I said now after 1995 I decided to resign from the science teaching and go straight for economic science. Not that really I do not have any love for science. It is still number one subject in all my sort of curricula of subjects and so on. But the approach which is highly hundred per cent a theory without any practical perspective possible has made me resign science teaching that only this year now I had to come back to science teaching to rescue the standard tens for the sake of no teacher is sort of readily available from the Department of Science and so on. And of course since I stilformation themselves.

To the principal.

I will thank you again on record for the opportunity to interview your teachers and students. What I see here is the main problem that the students say they have no laboratory and up to now have not had a chance of doing even a single experiment. And you know, that, they are really complaining about that and as I can see the laboratory is a staff room and the store is your office. What do you say about this? What can you add to ….?

The Principal

Yes, it is a problem in running the school more especially with the Science Department because the supposed laboratory is used as a staff room and the store an office. This makes it difficult for the teachers to perform the necessary experiments. Even in cases where we have material by way of chemicals then it becomes difficult to organise students into the laboratory because it is always occupied by teachers. So it is in a way handicapping the subject. Almost up to now it has been difficult for them to perform the experiments and due to, of course not only the absence of the laboratory, but also the numbers in the science academic classes that is in the classes. The numbers are big. We are accommodation plus minus sixty something students in standard 8. That class is supposed to be two groups in reality in order to get a chance of giving individuals attention to students when performing experiments. This is brought about by the fact that a building that was burnt down in 1993, it has not been repaired. And we have been pestering, asking the Department to look into this. Last year they promised but due to financial constraints, it has not received the attention it should be receiving.

Standard 10A class (also present were the Principal and all science teachers)

What do you say about science?

Student A

No laboratory, we are just memorising science without experiments is useless.

How many experiments have you done?

Whole class in chorus None.

Student B

There is this problem of lack of a laboratory. We are trying to prepare ourselves for the future. What is important is to do something using our hands. Without using our hands, we will fail to be one of people in our country.

Principal

Can they speak in Xhosa?

Yes

Student B speaks again at length with more confidence in Xhosa repeating what he said earlier in more detail.

Standard 9 A (in presence of science teachers)

Teacher A - after introducing researcher remarks "you can see that the desks are up to the chalk board. Even if you wanted to do experiments, it is impossible".

(Students said that science was not easy because they do not have a laboratory. They said that they wanted to see what happens. For example, when Hydrogen combines with Oxygen to form water. They thought that science was necessary for use in everyday life and also for finding jobs - jobs are scarce).

3.3.1.2 Second Interview - with the science teacher/principal (School B)

So you are the science teacher and principal as well?

Yes yes.

So what would you say are your problems in science? By the way I am recording already.

Pardon?

I am recording you already

Ah … I do not have problems because really I was made to understand what I am doing by SEP previously. The only problem I have is the kit. It is not enough for students for groups. As you see each of them is just 2 of them - out of say forty students. Meaning that it is not easy for them to perform experiments on their own. Otherwise if I happen to make them work individually, it cost a lot of time. Only 2 students will do in thirty minutes. Say we are preparing Oxygen. Not all of them will be able to prepare Oxygen in that specific period. So we need more of it.

About how much more?

Say if we would have 5.

Five sets of each?

Five sets. Yes. At least it would ……8 students would form a group.

But, What I wanted to understand is whether the kit is enough for the whole syllabus.

No. it is not enough for the whole syllabus because we have a shortage of chemicals. As you see, not enough chemicals are there. We don’t have Sulphuric acid, Hydrochloric acid for Standard 7, is scarce.

Now, what do you have here? Let's just go through this quickly. This is a light kit.

Yeah it's light kit

What is inside there?

This is complete light kit.

And then that other one?

This is a chemical kit.

A chemical kit.

You see that we don't have enough chemicals there.

But I see that you have, for example, … What do you do with these? … These plates here?
Hmm. It's for showing the conductivity.

Okay
That metals are conductors. Standard 6 work.

Okay. It seems this is Copper.
Yeah it is Copper.

Probably Lead and Zinc.
Its Lead and Zinc.

And then inside there? Some of those chemicals. Sulphur, and Sodium Chloride, Iron, Cobalt Chloride, Copper again. Okay. Is this similar to that?
It is similar to this one. This one is similar to this one.

Okay. What else? I see there, you have got some for force and pressure.
For electricity too. Force and Pressure this one.

What is in there?
It is a manometer.

Okay. Alright
Plus tubes facing different directions. This is for Standard 7.

I see a balance. So this is …..You are going to have a class here?
It is a commercial class.

So you say you are now doing revision still?
Still doing revision this week.

So you will start again next week?
Yes.

This is the second week of….
Of opening.

Of opening. You say they just came this week?
Yes
Last week they were not here?
Tu! Just a few of them.

Why were they absent?
They are on holidays. In Cape Town waiting for money. Parents pay on the twenty fifth. Parents pay on the twentieth. Buses leave on Mondays. That is their story.

So may be it could be better for the terms to start after payment. After, you know … when you open?
No. I wouldn't say they should start that time. At least some come, some don't. We have to repeat what we have done - you see. We can't say no we are going to carry on with our work. Those who are absent will suffer. Because when they come back, they narrate their stories to their advantage. Parents do not have money. In rural areas we have got those stories.
Students came during this second week.

Okay. The TELMAST project. What would you say you have learnt from it?
TELMAST?
TELMAST. Yeah - the one that was at ….
Oh. Nothing new really. It is just a continuation.

Continuation. Okay. And what kind of workshops would you want?
We would like workshops where we can be … we can have different approaches to different lessons. Say improving our approaches. We would like to have that type of workshop.

Like how? Practicals? Yes?
You can approach this, this way. If it fails, you can do it this way.

Oh. You want alternatives.
Yeah
It is unfortunate that I could not get a science lesson. May be one day I will come back. Because now you are revising.
We are doing revision in Standard 5. I have a period in Standard 6. The last period Standard 7. The last period Standard 6, the second last.

But it will be revision still?
It will be revision.

Okay. You have got a problem? With assembling?
Hmm

With?
Assembling.

Assembling
Assembling. I used to have one, which is not similar to this. But unfortunately, somebody broke in as you can see this pane is not similar to other panes. And he fetched the small pieces I used to use when measuring the mass. So it is incomplete - that old one. I got this one - this new one but cannot assemble it.

Can't you actually try? Then may be I will be able to help you as you go along.

(Laughter). I say no…. You do this and that, otherwise really I cannot. I do not know how.

When it was brought - or they just brought it - or?
Hmm. It was this type of kit, which was brought to me. I didn't notice it was different from the old one.
(Introduction researcher to another Standard 2 science teacher)

Is she not going to help us to assemble this thing?
(Laughter. The other teacher left without even coming to us to look at what we were trying to do).

Are you sure this is complete?
I don't know. I got it like this. Nothing is missing.
(This interview continued with the researcher assembling the balance successfully and asking the teacher to dismantle and re-assemble. The teacher thanked the researcher for helping her to assemble the balance).

3.3.2 Class visit. Video recording and STOS application

A lesson on using the Ammeter to measure electric current (School C)

A teacher delivered a lesson on the use of the Ammeter. The teacher had one set of circuit board, which he proceeded to use at the front of the classroom to demonstrate how to use an Ammeter with the help of three girls. The rest of the students did not touch or closely see the Ammeter.

The teacher talked most of the time and wrote on the board. The teacher's statements were authoritative telling learners the knowledge. The teacher selected the learners that connected the electric circuit. It appears that the teacher had 'trusted' learners that he knows would connect the circuit correctly.

Students answered a few questions. Most of learners were not communicating with the teacher and did nothing throughout the lesson. However, considerable whispering happened between learners. It was also notable that learners had no books or work sheets to record the observations. Therefore it seemed that the teacher prepared this lesson specifically for the video recording.

Table 1. <u>Results from STOS applied in a lesson on electricity</u>

One teacher was observed teaching about electricity to Standard 7 learners near Kentane. This lesson was also video recorded.

ACTIVITY OBSERVED	SEQUENCE OF EVENTS - MINUTE INTERVALS																									REMARKS
Time in minutes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1. Teacher's statements, - facts -problems, -speculation, -procedures	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	Std. 6 work at introduction. Measuring current in a circuit Introduced the Ammeter. Cells in series. Bulbs brighter
2. What is done about teacher's ideas? -are they questioned? -are they modified?																										Learners did not question the teacher or modify his statements.
3. Does the teacher entertain learner's ideas? -How?																										None
4. Is an idea followed through to a useful conclusion?																										Not applicable
5. Is there a daily-life context/influence or relevance of the practical? -is this mentioned?																										None
6. Does the teacher initiate all activities?																										The teacher initiated all activities.
7. Do learners initiate ideas that differ from those of the teacher? -What does the teacher do about learner's ideas?																										None
8. What kinds of questions do learners ask? -open-ended, -closed																										No questions were asked. The teacher was probably repeating this lesson.
9. What kind of questions does the teacher ask? -open-ended -closed										✔			✔													Teacher asked closed questions followed by "Why"
10. Kind of skills developed																										Observation?
11. Group work - --size of groups --any criterion or characteristics of groups, --Participation of teacher in learner groups																										There was no group work. The teacher complained of shortage of apparatus for lack of group work.

3.4 Summary of results

3.4.1 Questionnaire

A1 shows that teachers no longer follow the same sequence of topics in the textbooks or scheme. For example, electricity appeared 8 times as a topic that teachers had already taught although electricity does not appear among the first topics in the textbooks, particularly high school textbooks. One may assume that electricity is a popular topic probably because it can be taught practically according to results in A2.

It also appears that more Physics topics were covered by the second quarter than chemistry (and Biology in case of Junior schools in which biology is part of the 'science' textbooks). These included Motion & Vectors (5 - all in High schools), Atomic structure/Periodicity/Bonding (4 times), Work, Energy & Power (4 times) and Light (3 times).

A2 shows that 3 teachers indicated that they have not done any experiments. B9 indicates 5 times that experiments do not always work although 2 teachers believed that their experiments always worked. Electricity appeared 6 times among topics in which experiments were done (A2) and electricity appeared 6 times among experiments that worked well (B10). Other experimented topics included 'Chemical Reactions' (3 times), Force (2 times), Electrostatics (2 times), Light (2 times) and Pressure (2 times). It may be necessary to find out the experiments that were carried out on these topics and how such experiments were done because the learner's exercise books did not show any records of these experiments. On the other hand, learners did not have any books in the class that was video recorded. Perhaps some experiments are done without the learners recording anything.

In A2, teachers indicated that they carried out experiments in Force (2 times), Chemical Reactions (3 times), Measurement (1 time) and Combustion (1 time) although these topics were not listed among those that had already been taught. The implication is that teachers probably consider these topics to be subtopics of those listed in A1.

Topics that appeared in A1 but not in A2 would be those that were taught without practical work. These included Work, Energy & Power, Atomic Structure, Periodicity & Bonding, Flowering Plants, Salts, Waves, Phases of Matter and Acids & Bases.

A4 shows that lack of apparatus as the reason for not organising practical work was indicated 10 times, while lack of time appeared 1 time. This is supported by the fact that only one school had a full set of apparatus for almost all experiments. The importance of apparatus was reiterated in B11 (availability of apparatus made experiments easier, 4 times), B13 (scarcity of apparatus made experiments difficult, 8 times), C3 (availability of equipment will make application of knowledge gained from workshops possible, 3 times), C4 (insufficient apparatus will make it impossible to apply knowledge gained from workshops, 6 times) and C5 (CASME should supply equipment, 2 times). It appears that teachers attach much importance to equipment or apparatus.

The teacher's belief that the availability of apparatus made experiments work easily was equally important as the prior practice and experience (B11). However, although scarcity of apparatus was believed to be the main cause of making some experiments difficult, lack of prior practice was not mentioned among problems that make experiments difficult (B13). Perhaps teachers did not realise the importance of lack of prior practice because they did not have apparatus. Alternatively, teachers did not think that lack of prior practice is a problem, although teachers perceived prior practice as an advantage that make practicals easy. However, lack of knowledge to organise practical work appeared 2 times (A4).

In B, learners appear to have the liberty of starting and conducting practical work by themselves (7 times in B1), making predictions (9 times in B2) and of supporting their predictions (by whatever means) (10 times in B3). Teachers indicated that they preferred not to tell learners what to see in the practical (8 times in B4) but mostly record the results that learners obtain (B14). However, the video-recorded lesson and the learner's record books did not support these claims.

Teachers expected learners to acquire a wide variety of skills from practical work. Some of the listed skills are not easy to understand, such as self-discovery, cognition and understanding. Observation appeared most (9 times), followed by Reasoning, cognition & thinking (5 times) and listening (4 times). However, few responses (5 times) indicated that the planned skills were acquired (B6). Thus some of the skills or significant proportions of the expected skills could not be acquired. Nonetheless teachers claim to test for these skills even though they knew that learners did not acquire those skills (B 8). On the other hand, the responses in B6 could be a reflection on results, for example, after tests. One test that was inspected did not include many of these skills. Hence teachers may not know how to test for these skills and may not know whether such skills were acquired or not by the learners.

Teachers indicated that they try the experiment again if the experiment does not lead to expected results (6 times B16). Other teachers discuss why an experiment does not work (3 times) as opposed to teachers who prefer to tell the 'truth' (2 times) or to stick to the textbook (1 time).

3.4.2 STOS

The lesson was teacher centred. This is indicated by the fact that items in the STOS form that dealt with learner participation, 2, 3, 4, 7, 8 10 and 11, are blank. That was because the teacher talked throughout the lesson. The teacher's questions were closed with definite answers such that answers could not be debated.

3.4.3 Video Record

Discourse analysis of the interviews at schools A, B and C

It should be pointed out that a full discourse analysis of the above interviews would take more time and space. Many of the statements and body language will not be analysed here. Hopefully, analysis will continue, especially with more research. However, the words typed above do not show the emotion, sarcasm, body language and tone. A better interpretation can only be obtained by watching the recorded video record. Furthermore, spoken English looks funny when transcribed.

The discussions show that teachers, the researcher and students all have a problem with expressing themselves in English. For example, the atmosphere was livelier when students started to speak in their mother tongue (Xhosa). Unfortunately, the student's Xhosa discourse was preceded by teacher's laughter that seemed to make a mockery out of speaking in Xhosa in a classroom. Nonetheless, more information came from the same student when he talked in his mother tongue.

All statements are emotional and demanding. The author could have been perceived (and introduced himself with that profile, unfortunately) as an agent that will take the problems to the people that can solve them. Statements are loaded with frustration, which is demonstrated in the first interview by the teacher's refusal to attempt practical work.

In the First Interview, a statement like …"Truly, I am interested in science but left for commerce …" is defensive. It is prepared for people to appreciate the teacher's reasons to switch over to commerce. The same teacher said, "…I was tired of the teaching of science in pure theory." Yet commerce is more theoretical than science. Hence, apart from his stated frustrations, there could have been other reasons for his leaving science. It was also interesting that he was waiting for somebody and did not seem to associate himself with science. …"I am just helping….". It is not clear how he expected this somebody to manage science teaching where he failed. There could be insecurity that the teacher felt when he attempted to teach science.

Other teachers and the principal seemed to echo the first teacher. Male Teacher A appeared to be a dominant factor whose interpretations of problems in science education at this school were respected or feared by other science teachers, students and the principal. It was established that Female Teacher B who declined to talk was new at the school and that Male Teacher A was the oldest in science. Male Teacher A had apparently successfully convinced other teachers and students about the reasons why there can not be practical work in science.

While teachers in the First Interview complained of the problems involved in group work, their students indicated that they have never done any practical work. Therefore, the teacher's fears were theoretical because they have never tried practical work and probably even group approaches.

The teacher in the Second Interview had a problem with expressing herself in English too. Students were spoken to in their mother tongue. This teacher played down her problems by saying …"I have no problems". and also saying …"I learnt nothing new from the TELMAST workshop". There was a degree of pride or lack of appreciation of problems in those statements. The workshop that she was talking about had dealt with electricity and making of electric cells as well. The plates that she thought were for conductivity had been used to prepare the cells. Those plates are not normally packed with the chemical kit that she had. There is a possibility that she picked up those plates from some workshop. Her problems came out only after further probing. May be she was proud because she was also the principal of that school and did not want to give an impression that she was failing.

This teacher also showed lack of initiative in the statement … "…otherwise really I cannot. I do not know how". This statement implies that she expects to be shown how every new apparatus works. The statement also apportions blame to those who supplied her with a balance that she did not know how to use.

The same teacher sounded sympathetic to the students' inability to report back to school in time. She was the only one that related problems to the economic problems which she believed are found in rural areas in the statement … "parent do not have money. In rural areas we have such stories". However, earlier on she had said that students delay at Cape Town where they wait for their parents to be paid. Firstly, this would imply that students leave their parents in rural areas to go and visit Cape Town or that some parents live in Cape Town but left their children in the rural areas - in both cases students had to seek for money that was apparently hard to get. Secondly, her sympathetic statements that were delivered with sorrowful tones about students again demonstrated her feelings about a people that were helpless with no money, being neglected by some powers.

In summary the video record includes

i) Interview one

Teachers believed that problems with teaching science were due to lack of a laboratory, apparatus, electricity and tap water. The record shows that there was much apparatus in the store that was turned into a principal's office. Learners admitted that they had never done any practical although they thought that science and practical work were important.

ii) Interview Two

This teacher said that she had no problems but later on started to bring out some issues like few kits and late coming of learners after holidays. She also had a problem with assembling a balance. The teacher picked science kits from underneath the table and underneath a stack of books. Kits were also dusty. This was evidence that she was not frequently using that apparatus. It appears that this teacher did not wish the researcher to know of her conceptual problems but blames every problem on poverty.

iii) The Class visit

The teacher talked authoritatively throughout the lesson, using the chalk-talk method, while learners kept quiet. The Video Records show that learners (and teachers in the workshop) were often passive. This pattern in the lesson was similar to the pattern in the workshop where the subject advisers kept teachers passive in a workshop.

3.4.4 Other data

Evidence from other CASME workshops for the Open Foundation Society conducted to find out from teachers what their needs are, confirmed some of the teacher's beliefs above that their problems are mainly caused by lack of apparatus, lack of knowledge to use apparatus, lack of laboratories, few workshops, large classes and shortage of time. Again many believed that the government or an NGO had to provide all these needs.

There was no evidence of use of the apparatus where it was available. There are admissions by some tertiary institutions in the Eastern Cape and from FDE students attending at Rhodes University that there were no practical experiences for science teachers in training. At the school where I taught in the South East Region, the laboratory gradually became a store again after I left. Another high school in the region also has its laboratory turned into a store. That made it 3 schools where laboratories were made obsolete.

3.5 Evaluation of the Instruments

The advantages of each of the instruments used that were mentioned earlier in Chapter 2 above were realised. In this section, the shortcomings of each of the instruments are reported and where possible analysed.

3.5.1 Questionnaire

Foremost was the assumption that all respondents understood the questions in the questionnaire. Although the questionnaire was read through with the teachers in the research workshop, the author is not sure whether that improved the teacher's understanding of the questions since proceedings in the workshop were conducted in English.

The questions were too open to the extent that answers to them could have a wide range of interpretations. For example, question 2 (part A) required topics in which teachers have used experiments. Firstly, teachers responded with wide topics such as Electricity and Chemical reactions whereby one is not sure which part of these large topics were dealt with practically. One assumes that teachers carried out ***all*** the prescribed experiments in such topics.

Secondly, some of the recorded topics do not have known easy experiments especially using school equipment. For example, the inclusion of momentum among topics, in which experiments were conducted, leads one to suspect that teachers may not be telling the truth. Furthermore the questionnaire has no capacity to reveal how the experiments were done.

3.5.2 STOS

STOS (Appendix III) proved to be hard to follow because many things happened almost at the same time such that it was difficult to record the activities properly. The duration of each activity could only be estimated.

Some of the activities were not represented on the STOS form. For example, there were communications between learners, learner's body language, tone of speech, activities and facial expressions that could not be recorded, because such expressions were not catered for in the STOS. The STOS remained blank during activities that were not directly related to the lesson - STOS could therefore give the wrong impression that there were no activities in the class or that only the teacher was active. The records in STOS did not reveal the emotions and emphasis in message from participants. Video recording was therefore a necessary triangulation measure for STOS to capture that extra data.

3.5.3 Video recording

The video could not be used properly in the absence of electricity in remote rural areas, where for example, the classrooms were rather dark for clear recording. There was no way of recharging the video batteries. The video also required a remote microphone.

The other disadvantage was that learners tended to concentrate on the video and therefore on the author rather than go on normally with their studies. There were also signs of teachers acting for the recording.

3.5.4 Interviews

Open-ended questions yielded very long answers and answers that were not directly related to the research topic. This made the transcription of video records tedious especially with the effort to pick out information that was relevant to the research topic.

Teachers and learners frequently interfered with the interview. The interview had to be suspended until the interruption had ceased. Interrupting an interview often changed the mood and course of discussion.

It appeared that asking teachers for their problems outright could have created a bias that gave a picture of doom in science education - it meant that there were problems that teachers have to discuss. Therefore teachers who could perhaps not see any problems were indirectly forced to say something bad about science education.

It was better to ask for comments about science teaching. Even then the author might have been viewed as somebody that could provide remedies to the teacher's problems since he was working for an NGO that had once tried to solve such problems.

3.5.5 Discourse analysis

Discourse analysis required the author to have a good command of English or to be able to interpret correctly the meaning in the statements made by the interviewees. The interpretation of statements by interviewees was also influenced by the author's thinking patterns and past experiences. Therefore another researcher may analyse the above discourse totally differently. The differences in interpretation make discourse analysis a subjective process that is embedded in interpretativism. That is, discourse analysis can not be objectively executed.

3.6 Possible improvements methods and research instruments

3.6.1 Questionnaire

It may be better to concentrate on fewer aspects. For example, the research could narrow its focus on problems in one science topic such as 'electrostatics'. This will result in questionnaire that deals with problems in more depth.

Furthermore a shorter questionnaire is likely to be accepted and to be answered more truthfully by teachers while at the same time giving more clarity on the chosen aspects.

Teachers should have been informed that the research included Biology. It appears that biological topics were not included among their answers.

3.6.2 STOS

Similarly, it may be necessary to try out STOS that deals with fewer aspects. STOS could be made more relevant and contextual if many pilot applications are made in these schools. Such STOS will contain items that are expected or more frequent in these schools.

3.6.3 Interview

The interviewer should perhaps be an ordinary person, although teachers may not be easily convinced to talk seriously with such a person. Teachers may interview each other more effectively and may bring out serious and urgent issues from fellow teachers easily because they are part of the teaching fraternity. Future interviews should involve teachers in interviewing while the author would act as an observer, doing the recording.

It appears that more information can be obtained if vernacular is used during interviews. It might be better then to employ an interpreter that will translate that vernacular into English.

3.6.4 Video recording

A more powerful video camera that can pick up pictures in dim light is necessary. It should also have many batteries or batteries that can last long, and a remote microphone.

It is necessary to plan pilot video recording sessions. These may enable proper recording in the main research and will make learners and teachers to be used to video recording so that they do not concentrate upon the act of video recording when the main records are being done. Unfortunately frequent piloting may alter behaviour in the classroom to the extent that the records will not be representative of other 'normal' classrooms.

4 DISCUSSION OF THE RESULTS

This was a small-scale research project that one can not draw general conclusions about the approaches and problems of science teachers in rural areas of the Eastern Cape province. However, some trends can be noted, especially if these are put in perspective of the author's teaching experience and outreach work in similar schools.

Electricity appeared to be popular in the questionnaire responses. Appendix V shows that electricity appears in the standard 4, 6, 7, 8 and 10. Therefore the higher frequency of electricity in the questionnaire results could be due to its appearance in many standards. For the same reason, schools are also likely to have equipment for teaching electricity and to attempt to use practical means to teach electricity. However, in an earlier investigation (Appendix IV), the highest percentage of Matric students marked electricity as the most difficult. This claim was confirmed during a workshop on the 15th September 1998 to help Matric science teachers by Mr Moloi, the examiner for Physical Science (Standard Grade Paper 1) in the Eastern Cape Province, who stated that electricity was one of the most failed topics. Butts (1985), Kuiper et al (1985), and Smit (1993:222) also pointed at serious misconceptions about models in electricity. Further research and solutions are necessary in school electricity because it appears to be among the most difficult topics despite being the most frequently approached by practical experiences.

4.1 Discussion of research question 1
What do teachers in the South East Region of the Eastern Cape Province perceive as problems in teaching science?

4.1.1 Material problems

Material problems seemed to be related to academic, social and economic standards of the rural areas where this investigation was done. The author's findings agreed with data in Appendix X in that only 24% African (Black) schools in the South Eastern Region had electricity and only 23 % had laboratories – almost all schools in rural areas are African. Therefore, rural schools where this research was done are not likely to have electricity. Electricity is just one of the indicators of a low social economic standard. Low economic standards can contribute towards lack of materials in schools.

However, apparatus and laboratories should not be pre-requisites for science teaching. An innovative teacher can find interesting materials and phenomena in every environment that would even be more relevant to his learners. Apparatus can be borrowed from neighbouring schools and from Subject Advisers. Thus, the excuse thrown upon lack of apparatus might be a cover up for lack of science practical skills, especially because teachers who had apparatus were not using it to teach. This view is supported by the fact that one teachers did not know how to assemble a balance or even know the use of some of the materials in her science kits. Science teachers often struggle to work independently with some equipment and experiments.

The community in these areas does not have the capacity to question teachers on academic matters, particularly that which relate to science. In the author's teaching experience, parents rarely attended meetings at Lamplough High School, nor did agendas include fund raising or laboratory apparatus. The author was however required to attend meetings that involved debating about and raising funds for school equipment as a parent at Stirling High School. The video-recorded interview with one principal shows that he does not mention any role by the community and did not mention any attempt by the school to solve problems. The principal blamed the Department of Education for all the problems.

Parents in these rural areas may not be aware of the intricacies of school apparatus or the need for practical approaches and electricity. They might not have been informed of problems relating to the laboratory and apparatus. (Another survey is needed to establish the parent involvement in school matters). Neither would they have enough money to participate in acquiring such facilities. In the video-recorded interview, one teacher claimed that parents have no money, even for fees. Another indication of their financial plight was a building that had not been replaced after five years - an initiative to renovate that building would be forthcoming if parents cared or had money for renovation. Five years is a long period if compared, for example, to a building that was burnt at Clarendon Junior School in East London in 1993 that was replaced within a year and students had alternative accommodation at Sterling Teachers' Centre.

For a community to realise a need for apparatus, it must be educated on its use and relevance. Alternatively, community members ought to have used such apparatus when they were at school. Unfortunately, on the basis of claims made by FDE Science Education candidates at Rhodes University, that they had never even touched some apparatus, few community members in rural areas could have ever seen science apparatus. It is the science teachers, such as the FDE candidates, that would advise the community on apparatus - only the video record shows that teachers do not seem to know this apparatus either and how it works. Besides, much of the school apparatus bears little resemblance to appliances that are useful in a rural setting. Thus it is possible that laboratories and apparatus are not priorities in rural communities, these being foreign and possibly irrelevant in that environment.

The teachers' belief in apparatus emphasises its foreignness and the fact that 'science' is an imported concept into such communities. Teachers and the community know how to teach locally developed or indigenous knowledge - for that they do not only improvise or innovate but can develop equipment and new methods. For example, they are able to construct houses that seem to be suitable for the climate in these areas. The lack of innovation to use alternative apparatus and alternative practical approaches in the science classroom could be an indication of misconceptions about apparatus or science knowledge. These misconceptions arise out of poor teaching which teachers received and from the fact that school science is rarely applicable and therefore is unpractised in rural environments. Hence apparatus was found gathering dust (First and second interview) in the few schools that were privileged to have some, because teachers have never done practical exercises and teachers do not know how to put apparatus together. For example, a teacher expected somebody to come and show her how to assemble a balance.

That this teacher stayed with a balance that she could not assemble for years could have been an indication of lack of motivation, or of an indication of lack of knowledge of science processes. Lack of motivation and science processes may highlight the possibility that teachers take science knowledge to belong to other people, such as Whites and Subject Advisors. Thus there is a gap between these teachers and science knowledge that is passed on to their learners. The gap was illustrated by the learner’s submissiveness (or passiveness) and authoritative nature of the teacher in the STOS results and the authority exercised by Subject Advisers over teachers in the video-recorded workshop. Results show how teachers and learners feared or respected 'science' and those who claim to know it.

The gap is exacerbated by the belief that science is inside apparatus in a laboratory and 'science' is behind every 'magical' phenomenon such as when electricity lights up a bulb or drives something in a car. People believed to be 'experts' like the author and subject advisers are called upon often to demonstrate science, and arrive with apparatus. (It should be noted that many of the machines and cattle diseases are often described by 'scientific' names and 'scientists' often live in town). Science thus acquires a mythical status that has to be respected particularly because it is not clearly explained and understood. African indigenous culture does not also contribute to science learning.

Possession of science knowledge can be perceived as possession of power - power to change the environment and thinking processes of other people. People in villages have indeed observed that some scientist has to be called upon from town to restore order in a machine such as a water pump that is not working, or to treat cattle of some disease. Many people, particularly politicians, often claim that their recommendations are backed up by 'scientifically' proven information when they want to convince the public. Therefore, perhaps teachers and learners are justified to feel that they have to complain to some power above. For they do not own 'science' and its problems.

4.1.2 Problems concerning conceptual understanding and knowledge

Although this research was not set out to test conceptual problems that teachers have in science, the reasons for not carrying out practical work given by teachers point at lack of conceptual understanding apart from other problems such as motivation. This view is further supported by the results in the questionnaire which showed that although electricity appeared to have been taught by practical approaches most (Part A2), electricity was deemed to be one of the most difficult topics in Physical Science by students (Appendix IV).

Of the six teachers that supplied their qualifications, three had no formal training in science. Such teachers depend upon their school science knowledge to teach. However, even those that qualified in science education seem to have missed practical experiences. For example, FDE (Science Education) teachers at Rhodes University and some lecturers in some teacher training colleges admit that there were no practical experiences for teacher trainees. Therefore, teachers may not be able to approach science practically because they may lack conceptual understanding as a result of lack of practical experiences. For example, a teacher could not attempt to assemble a balance. The same teacher believed that the metal plates were to test for the conductivity of electricity although those plates are traditionally used for making electrochemical cells. This view is also supported by the lesson that was so structured as if to avoid any student input and questions.

Teachers generally gave the impression that they did not have problems with conceptual understanding. For example, one teacher said that she had no problems and that workshops only dealt with the usual. This is the same teacher who did not know the use of the metal plates. Other teachers gave the impression that they fully understood the use and need for apparatus and a laboratory. Such teachers are far from the current trends that question the use of laboratories and practical approaches in classrooms.

4.1.3 Other problems

At the time that the researcher was teaching, the teachers in the name of transformation of education rejected common schemes that were used by the former Transkei Education Department. Common schemes were considered as means of government control because subject advisers without teacher participation were then designing schemes. Now, there seems to be greater independence of teachers in starting with any topic. This independence may complicate inspection schedules of subject advisors and workshops. Because each teacher often deals with a different topic, a topic dealt with in a workshop may not be of immediate use to all teachers.

Science education in the schools where this research was conducted appeared to be greatly affected by mismanagement of schools. For example, a school closed before midday and many others commenced classes late and had lengthy breaks between periods. Students were reported to return during the second week after opening schools. A school was found in huts. These problems showed lack of proper management and inspection of schools.

There was only one teacher (Second Interview) who pointed out that the income of parents caused problems in her school. Her point is supported in Appendix VI, which shows that 65% of out-of -school youth in the Eastern Cape left school due to lack of money. Although this data refers to older students, it can be assumed that money could be a major contributing factor to the problem of late coming of students after opening. Late coming delayed progress in science lessons because the teacher said that she had to repeat lessons for late comers.

Another apparent problem was that of expression in English language. Interviews showed that teachers had a problem with speaking English. One suspects that they therefore teach in vernacular. Many science concepts have no translation in vernacular and any attempt to translate science can lead to misconceptions. For example, energy, power and force can all be translated by the Xhosa word 'amandla'.

Similarly, the video record shows that learners could express ideas better in their vernacular, Xhosa. This confirms Kurian's (in SAARMSE 1993:87) finding that English being a foreign or second language to most pupils, especially the rural pupils, made it difficult for them to understand questions and to express their ideas in English.

During workshops, teachers also often complained of the differences between common English usage and science concepts. In science, Weight or heaviness is a force that is measured in newtons. Commonly, people refer to heaviness in kilograms, possibly because common consumables are sold in kilograms.

Other problems such as over-crowding are economic problems that affect science education in these schools. Appendix VIII shows that the learner-classroom ratio in the South east region is 66, in agreement with the teachers' and principal's claim of having 'sixty something' learners in Standard Eight.

4.2 Discussion of research question 2

What approaches do science teachers in the South East Region use in science lessons?

Approaches were apparently affected by teacher's problems. For example, there was only one circuit board in the lesson that was video recorded. Having a single circuit board was one of the reasons why only two students out of about thirty students touched the circuit board.

The teacher talked and wrote notes on the blackboard throughout the lesson, and the learners' note books did not show any record of practical approaches and speculation. Yet in the questionnaire, this teacher clearly indicated that he gave opportunities to learners to speculate and to test their speculations practically. This observation agreed with findings by CASE that 55% of the out-of school youth in the Eastern Cape were taught by copying off the blackboard while only 11% asked questions (Appendix VII).

Similar to the way the teacher in the above paragraph conducted the lesson on electricity, the video record shows that the subject advisers were the main participants in the practical exercises during a workshop. Thus the practical approach in which learners are the main participants is a belief, a myth and remains rhetoric to teachers and subject advisers. One indeed wonders why teachers and subject advisers adopted the 'transmission' method contrary to their claims for a need to approach science practically. The disparity between beliefs and actual practice needs to be investigated.

Teachers listed many skills that learners obtain from practical experiences. All the listed skills are traditionally believed to be acquired through practical work. But such beliefs are rarely evaluated and so remain mere beliefs because educationists are still to find out how to evaluate such skills accurately. However, it turns out to be a serious problem if teachers genuinely believe that they are achieving these skills in their science lessons, even in situations similar to the science lesson that was video recorded (see paragraph above). That teachers believe that they achieve these skills could be the reason why they claim to test for these skills.

No two teachers listed the same combination of skills. If the list of skills is considered to represent the teacher's understanding of science, then the variation in the kind of skills listed could be an indication that each teacher conceived science differently. The problem with such differences is that approaches may differ accordingly between teachers to the disadvantage of learners who may move from one school to another and may work against centralised examinations such as Matric - the learner will not find any consistency and continuity.

Unlike the questionnaire responses on skills, the video record shows that the teachers' perception of practical approaches was for learners to 'feel', 'touch' and 'do things by themselves'. These perceptions of practical approaches seem to be narrow and problematic. For example, terms like 'feel' and 'do things by themselves' can have a wide range of meanings. It is worrying to imagine that teachers think that when learners 'touch', as a few of them did in a video-recorded lesson, then one objective of a practical approach has been achieved.

Teachers claimed that learners had opportunities to speculate and could try out their speculations. Although teachers believed in practical approaches to teaching science, few seemed to carry out those practicals since much of the apparatus was found to be dusty and the learner's books did not show any record of speculations and reports of practical work. Neither did the lesson and the workshop that were observed reveal any evidence of such skills being developed. Similarly, the teacher's complaint of large numbers of students in classes showed lack of skills for dealing with large numbers of students, although interviews revealed that teachers seemed to believe in group work. An approach that uses group work could solve part of the problem of large student numbers.

It is interesting that students narrated the advantages of practical approaches to science although they had never done any experiments. Their knowledge of such advantages is possibly obtained from textbooks or is again also taught to them by teachers.

This observation leads to the conclusion that teachers simply recorded skills in the questionnaire that they read somewhere and have not attempted to achieve these skills in their learners. The wide variety of skills possible may, on the other hand, imply that teachers do not agree on skills that can be achieved through practical exercises, and that their practical approaches lack consistency and direction.

4.3 Discussion of research question 3

What are the implications of problems and approaches of science teachers in the South East Region to OBE?

The Department of Education proposed a change towards OBE, as a way of improving education. The Department of Education believed that a change in the curriculum was more urgent and seems to have considered apparatus acquisitions as secondary to curriculum change during 1997. For example, it appeared as if the Department of Education had already informed the teachers that were interviewed about OBE. The principal in that school however claimed that the Department of Education had not attended to replacing a building that had burnt some five years ago, claiming that there were no funds. Results show that teachers do not share that same order of priorities as the Department of Education.

Similarly, while CASME spends more effort in inculcating practical approaches in teaching science and in improving the teacher's conceptual understanding, teachers seem to be more interested in obtaining apparatus from CASME. It could be true that workshops repeat the usual as the teacher in the second interview claimed. In that case CASME is misinterpreting the teachers' needs.

However, workshops and FDE sessions for Science Education at Rhodes University have indicated that teachers lack the conceptual understanding of science that is a pre-requisite for organising interesting practical experiences for their learners. Furthermore, none of the FDE students has ever demonstrated practical approaches to teaching science. Thus teachers do not perform many experiments.

OBE will not succeed in such an environment. OBE is threatened by the teacher's lack of conceptual understanding, lack of practical skills and lack of knowledge of the use of practical exercises as well as of apparatus and laboratories. Teachers also lack basic apparatus.

Teachers ought to learn about practical approaches as well as pure science. Furthermore teachers do not seem to reflect accurately on their practices. OBE requires teachers that will reflect on their classroom actions so as to plan for relevant and interesting outcomes and learning exercises. Teachers will have to change their practice and become reflective practitioners and researchers to enable successful implementation of OBE.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Although the results from this research are not generalisable due to the fact that the sample was a small percentage of the population, results showed close similarities with the problems and approaches of science teachers that were found by earlier investigations such as those by MacDonald & Rogan (1988). Results also agree with the author's experiences in teaching science in the former Transkei. This implies that there have been no significant improvements in the science classrooms since 1988.

Teachers have not yet practised practical approaches that institutions and the Department of Education try to recommend. The fact that teachers recited but did not use these practical approaches in their classrooms, might imply that they only read about recommendations on practical skills without hands-on experiences and were forced to believe in such practicals for the sake of certificates. Lack of science practical skills questions the adequacy of the teacher's training and qualifications in South Africa. The teachers received poor science education as students and as teacher trainees. Thus, few FDE (Science Education) candidates can attempt practical approaches even though they have Matric certificates and teaching diplomas in science. Fewer still realise the need for further training in science education because they do not think that they lack practical skills or conceptual understanding of science - for they have never tried science practicals.

The views in the above paragraph are in concord with CASME's (1992:35) finding that teachers agreed that practical approaches were essential for science teaching although many lacked laboratory skills. Thus the main problem of science teachers is that they lack knowledge on how to organise practical exercises, and how to use apparatus, but do not believe that they lack that knowledge. Teachers instead blame lack of apparatus and laboratories for their problems in approaches to science teaching. Hence teachers have often toi-toied for material needs rather than knowledge.

Apparatus and laboratories are important in science teaching but their importance seems to be misunderstood and exaggerated. The importance is an unpractised belief that is entrenched down to the students. However, because teachers interpret their lack of practical approaches to be caused by lack of apparatus rather than lack of practical skills in teaching science, the provision of apparatus and laboratories is not likely to lead to the use of practical approaches in teaching science. It is because teachers lack practical skills that teachers do not often use apparatus even when it is available in their schools.

OBE is in serious danger of the teacher's misconception of their problems and approaches (which are based upon their beliefs that apparatus as it appears in textbooks and laboratories are pre-requisites to practical approaches in science education). This belief defines the approaches that teachers can attempt and problems they believe they find in teaching science. Such a belief is characteristic of behaviourist-objective approaches of the CNE and Fundamental Pedagogics that science teachers seem to be using in their classrooms. This belief and the use of the CNE and Fundamental Pedagogics will bar teachers from critical interrogations of OBE approaches and is not compatible with OBE, such that it threatens the success of OBE. It is perhaps for the same reason that teachers do not seem to reflect upon their profession.

Results do not lead to conclusive evidence regarding approaches to science education in rural areas. A more valid comparison with urban schools can be obtained by replicating this research in urban schools. However, the results provide enough grounds to justify further research. This research should be continued in both rural and urban schools, perhaps with improvements in the research instruments and methods that are suggested in section 3.6 covering a wider sample but dealing with fewer aspects or topics.

The triangulation between questionnaire, STOS and interviews, together with video recording and discourse analysis, provided reliable and valid results and ought to be tried again in the same combination. For example, the video record proved that some of the teacher's answers in the questionnaire were mere beliefs. The best instrument seems to be the interview, especially if it accompanied by video recording as one can replay the events any number of times. Video recording was however the most laborious, particularly during transcribing.

The author believes that the research questions were adequately answered by the use of the instruments and methods that were used. The survey showed the science teacher's approaches and problems in science education and the implications they might have on OBE.

5.2 Recommendations

There is a need for consensus about priorities in science education among educationists, particularly between teachers and the Department of Education. Without consensus, the efforts by the Department of Education in introducing OBE may not bear fruit. For example the gap between the teacher's belief that their priorities are more related to material acquisitions rather than curriculum change and that of the Department of Education that a curriculum change will instead remove problems in education, needs to be narrowed. That calls for serious debates on curricula and material needs of schools.

Furthermore;

1. It is necessary to make an inventory of laboratories and apparatus in schools of the Eastern Cape. The inventory will provide data that will be used to identify the teacher's material needs. The Department of Education and NGOs should seriously consider coupling content and methodology with provision of the necessary apparatus when teachers attend in-service courses and workshops.

2. Teachers have to practice skills of using apparatus that they are supplied with and in practical skills. Teachers should also be taught how to make or improvise apparatus and how to organise practical work in the classrooms. Improvisation requires a clear understanding of concepts for which apparatus is being improvised. Teachers should be able to state why their apparatus works as it does. They should be made to understand that a laboratory is not necessarily a special building. However, teachers should be trained in practical and laboratory maintenance skills.

3. There have to be programmes that will make teachers realise the need for further education as a priority above the need for apparatus. Courses in science education, such as the FDE offered by CASME and Rhodes University, need to be more seriously advertised. This requires funds that will be specifically for advertisements. More science education workshops are also needed - although these may have to come with incentives for teacher. Teachers have to be shown that their problems are more related to lack of knowledge and skills rather than lack of apparatus and laboratories.

4. The Department of Education should re-introduce study leave for teachers that wish to attend courses in science education. It is in the same light that Dr Kuiper's suggestion for a provincial college of science education is highly recommended. Leave can easily be accorded to teachers that attend such a college.

5. An approach by which all problems are collectively solved in an integrated manner is necessary. For example, the provision of apparatus should go along with introducing teachers to better teaching approaches and improvement in school management. While attention is currently mostly given to curriculum change, particularly in terms of subject content and methodology of teaching, a further effort is needed in changing and developing the school as a whole organisation. Isolating solutions for each one problem may not have the desired impact. That is perhaps why CASME workshops were not considered to be useful to one teacher. This teacher clearly needed apparatus and knowledge about how to use apparatus.

6. The implication of these findings to OBE is that teachers need to reflect upon their professional practices to the extent that they will be able to appreciate the authentic need for OBE. OBE could well be the curriculum by which teachers and students will be able to design their own apparatus and laboratories. The introduction of OBE will however work better if the administration or management of the school as a whole is attended to. For example, there appears to be a need to change the timetable of the school.

7 Science education should find ways of using simple English and of translating concepts into vernacular. Courses for science teachers may have to include remedial English.

6. REFLECTION ON THE ON THE RESEARCH PROCESS

The research was a lengthy process that involved many actors. I am therefore greatly indebted to all those who contributed to this research. It nonetheless reminds me of the difficulty involved in convincing other people of one's intentions in research. There were occasions of serious misunderstandings between me and other participants, particularly the M.Ed. candidates and supervisors. These occasions highlighted problems in social constructivism and objectivity in research. The end of this research left me wondering about how much of its planning can genuinely be taken to be mine. But since it had to involve other people and the results are likely to benefit all people, sharing ownership is necessary and welcome.

The findings were to a great extent a revision of my past teaching experiences in the former Transkei. Results confirmed that my experiences were common to other science teachers. However, I wonder whether I would have responded the way teachers in this survey did, giving similar excuses for not doing practical work with learners. Thus a question of whether teachers were saying the truth bothers me greatly because all conclusions are based upon their responses which could have differed from mine.

The opportunity of looking at the approaches used in science classrooms after leaving teaching was enriching as I got a chance of criticising my own teaching practice. The findings made me to sympathise with science teachers who were expected to produce scientists although they themselves seemed to lack science knowledge and skills, apart from their lack of apparatus and laboratories. The findings gave me an opportunity to re-visit the approaches in my FDE lectures and in CASME workshops. At least I have more insight in the beliefs of the teachers. It was on the basis of findings from this survey that I resolved to increase the proportion of practical skills in both the workshops and the FDE. I also decided not to take the teacher's claims of understanding for granted - their understanding need to be evaluated continuously. I have made similar recommendations to CASME. It is exciting to find that my findings can be applied in my present work.

The research process was more demanding and involving than initially anticipated. For example, the failure to keep to the appointments was disturbing but was out the control of teachers. Therefore, the cost of the research process was grossly under estimated. Furthermore, there was a feeling of desperation when no results were forthcoming, against the background of the deadlines that were given by the supervisors and the desire to graduate. One is lead to believe that in research, expect anything to happen and budget for disappointments. Apparently, research can never go according to plan.

Writing out the research report is challenging especially because it involves interpretation of findings against data that one is tempted to alter, as new information becomes available. I realised that data can be overtaken by events. For example, at the time that I was recommending for an inventory of apparatus, the Department of Education was apparently trying to do just that and to supply schools with apparatus. Furthermore interpretation of findings has often changed as I read more journals.

The research instruments were more difficult to apply rigorously and interpret than expected. Answers to the questionnaire showed that questions might have to be more specific. One of the most difficult task was to interview without biasing the discussions with my own sentiments and past or present experiences. Furthermore it was difficult to stick to the same questions during interviews since each interview situation was different. In the process of trying to adapt the interview to each context, and making questions as humane as possible, different teachers experienced different interviews. The STOS did not cater for the actual activities in the classroom. Thus better interpretations of the interviews and STOS require watching the video record. These are indications that human factors and contexts are important but are often not seriously reported about in research findings. Human factors and contexts also support the need to use qualitative approaches rather than quantitative data collection only.

The video recorded more than was intended and ended up with more data that was interesting but out of the scope of this research. This made it difficult to always remember to keep to the aim of the research. Thus there appeared to be a lot more happening in schools than anticipated which justifies more research projects.

It was worrying to find that nothing has changed since I left teaching. Although there are many projects in the Eastern Cape geared towards improving science education, it appeared as if these have negligible impact or remain rhetoric. It appears that further research is necessary to design new approaches that would have an impact upon science education. This view led me to wonder whether CASME does a fair but relevant service. The possibility that CASME may not be meeting the teachers' expectations or needs was scaring.

It was in respect of teachers' expectations that I continuously asked myself for the justification and benefit the research would be to the participants. It was hurting that the research had in the background my desire to complete the M.Ed. course that may not have direct benefits to teachers. My experience with educational researchers was that many carried the research out for the sake of obtaining a higher degree - I do not remember any researcher that came back to my school to bring back his findings and recommendations. A similar observation was made by Grayson (in SAARMSE proceedings 1996:7). Grayson stated that although the results of science research are commonly applied to industry, the results of science education research are not as commonly applied to education. I wondered whether I was financially and academically able to revisit the participants and give them relevant information from this research. I will try to play these tapes with the interviewees for further discussions with them.

Hence, I continuously interrogated the relevance and applicability of knowledge that I have gained from this research and from the M.Ed. course. What can I do after finding out the problems - how much impact can I make? Perhaps it is time that I start research from the interests of practising teachers - that is, from what teachers need to know about their practices that goes beyond the results of their learners. Therefore there may be a need to consult teachers before one writes out a research proposal.

Thus, I wonder whether the research questions brought out relevant issues in science education in the Eastern Cape Province. I still feel that I missed the most serious problems that hinder science education in the Eastern Cape Province. For example, knowing about the most difficult topics in science may not be helpful unless it is followed by further research into how to make those topics easier. I feel that there is a need to try out more research that will be based upon these findings. That is, this research would at most qualify as a pilot survey upon which a proper research project can be planned.

There were numerous fears. For example, the fear of whether the research was likely to reveal the 'true' story behind problems in teaching science. When the results started to come in, I realised that we all have a mammoth task of improving science education in the

Eastern Cape Province. There was also the fear that I lacked the necessary experience to carry out research properly and that my findings will be criticised and be thrown out as incomplete and irrelevant. However, after the experience gained from this research exercise, I feel more able to handle research and would gain from an extension of this research. I would change the questionnaire to be more specific and would write out an interview format for video records. The fear of whether teachers will be co-operative was unfounded. Teachers were surprisingly very co-operative.

In the final analysis, the experience gained from this research showed me that research reports seem to leave out much of the realities that may ordinarily be assumed trivial. Another person may need to visit my research site and watch the videos before he can get a realistic interpretation of the results. Similarly, I have adopted a more cautious approach to research reports by other researchers - I think little sense come out of these reports without visiting the research site, unless a graphic description is made of the context in which the research was conducted. Relevance of research findings may be enhanced by involving teachers in writing the research proposal and in the research design.

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Appendix I QUESTIONNAIRE TO SCIENCE TEACHERS

Part A. (Practical work that you can do at school)

1. Which topics have you taught so far?

----

2. In which of the topics that you have taught have you used experiments/practicals?

----

3. Which of the remaining topics do you hope to use practicals?

----

4. If there are topics that will not be covered by experiments, what are the reasons for not being able to organise practicals for those topics?

Part B (How you conduct your practicals)

1 Do you allow learners to start and conduct practicals by themselves?

----

2 Do you allow learners to make predictions?

----

3 Do you allow learners to support their predictions?

----

4 Do you tell learners what they are supposed to see?

----

5 What skills do you think learners acquire from practicals?

----

6 Do learners acquire the skills that you planned for?

----

7 Do you demonstrate to learners what they are supposed to do?

----

8 What science skills do you test for in learners?

----

9 Do your experiments always work?

----

10 Which experiments have worked well in your experience?

----

11 What could have made such experiments to work easily?

----

12 Which experiments do not work easily?

----

13 What could have made such experiments difficult?

----

14 What do you do with the results that learners obtain?

----

15 What do you do if an experiment does not lead to expected results?

----

16 What do you do if one student or one group gets different results?

Part C (Your opinion about CASME workshops - please feel free to criticise)

1 What have you found useful in this workshop?

----

2 Is it possible for you to apply the knowledge that you have gained in the workshop?

----

3 What will make it possible for you to apply this knowledge?

----

4 What will make it impossible for you to apply this knowledge?

----

5 What do you want CASME to add to the current workshops?

Appendix II

A MODIFIED SCIENCE TEACHING OBSERVATION SCHEDULE

ACTIVITY OBSERVED	REMARKS	DURATION
1. Teacher's statements - facts -problems -speculation -procedures		
2. What is done about teacher's ideas? -are they questioned? -are they modified?		
3. Does the teacher entertain learner's ideas? -How?		
4. Is an idea followed through to a useful conclusion?		
5. Is there a daily-life context/influence or relevance of the practical? -is this mentioned?		
6. Does the teacher initiate all activities?		
7. Do learners initiate ideas that differ from those of the teacher? -What does the teacher do about learner's ideas?		
8. What kind of questions do learners ask? -open-ended -closed		
9. What kind of questions does the teacher ask? -open-ended -closed		
10. Kind of skills developed		
11. Group work --size of groups --any criterion or characteristics of groups --Participation of teacher in learner groups		

Appendix III A MODIFIED STOS AFTER PILOTING AND DISCUSSIONS AT GRAHAMSTOWN.

ACTIVITY OBSERVED	SEQUENCE OF EVENTS - MINUTE INTERVALS																									REMARKS
Time in minutes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1. Teacher's statements, - facts -problems, -speculation, -procedures																										
2. What is done about teacher's ideas? -are they questioned? -are they modified?																										
3. Does the teacher entertain learner's ideas? -How?																										
4. Is an idea followed through to a useful conclusion?																										
5. Is there a daily-life context/influence or relevance of the practical? -is this mentioned?																										
6. Does the teacher initiate all activities?																										
7. Do learners initiate ideas that differ from those of the teacher? -What does the teacher do about learner's ideas?																										
8. What kinds of questions do learners ask? -open-ended, -closed																										
9. What kind of questions does the teacher ask? -open-ended -closed																										
10. Kind of skills developed																										
11. Group work - --size of groups --any criterion or characteristics of groups, --Participation of teacher in learner groups																										

Appendix VII Main reason for leaving school earlier than planned among out-of-school youth

Appendix IV
OPINIONS OF STUDENTS AT MASONWABE FINISHING SCHOOL ABOUT THE DIFFICULTY OF SCIENCE TOPICS

Table 2 Percentage of Students who marked each topic as the most difficult.

Standard 9 topics	Number/ %	Standard 10 topics	Number/ %
Displacement	1/**3%**	Newton's Laws of Motion	0
Force and Velocity	2/**5%**	Newton's Law of gravitation	1/**2%**
Speed, Velocity and Acceleration	2/**5%**	Momentum	3/**6%**
Motion (graphs & equations)	4/**10%**	Work, Energy & Power	7/**15%**
Light	1/**3%**	Electrostatics	3/**27%**
Light as an electromagnetic wave	0	Electric current	5/**31%**
Particle Nature of Light	0	Resistance & Ohm's Law	0
Basic concepts in Chemistry	2/**5%**	Transfer of energy in electric circuits	0
Developing the Atomic Model	0	Rate of chemical reactions	1/**2%**
Atomic Structure (Wave Model)	1/**3%**	Chemical equilibrium	5/**10%**
Radioactivity	0	Acids & bases	1/**2%**
Periodicity of chemical properties	0	Redox reactions	0
Covalent Bonding	0	Organic chemistry	2/**4%**
Ionic & Metallic Bonding	0		
Gases	1/**3%**		
Liquids & Solids	1/**3%**		
Sulphur & its compounds	**8**/**21%**		
Nitrogen & its compounds	0		
Halogen &halides	16/**41%**		
TOTAL	**39**	**TOTAL**	**48**

Table 3 Percentage of Students who believed that the following topics were easy.

Standard 9 topics	Number/ %	Standard 10 topics	Number/%
None easy	4/**27%**	Momentum	14/**67%**
Force and Velocity	1/**7%**	Work, energy & power	1/**5%**
Speed, Velocity & Acceleration	1/**7%**	Electrostatics	1/**5%**
Motion (graphs & equations)	3/**20%**	Electric current	3/**14%**
Developing the atomic model	1/**7%**	Chemical equilibrium	1/5%
Radioactivity	1/**7%**	Acids & Bases	1/**5%**
Covalent Bonding	1/**7%**		
Gases	2/**13%**		
Liquids & Solids	1/**7%**		
TOTAL	**15**	**TOTAL**	**21**

Appendix VII Main reason for leaving school earlier than planned among out-of-school youth

Appendix V Current syllabus topics - Std 2 to 10 (Grades 4 to 12)

General Science

Standard 2 (Grade 4)	Air, Water, Importance of air and water to living organisms, Plants and mankind, Animals and mankind.
Standard 3 (Grade 5)	Air, Water, Heating, Importance of air, water and warmth in seed germination, Reproduction, growth and development in plants, Reproduction, growth and development in animals.
Standard 4 (Grade 6)	Air, Water, Electricity, Plants as primary food source for animals, Feeding, Importance of conservation, Dangers of pollution with special references to air and water
Standard 5 (Grade 7)	Matter and measurement, Energy and energy transfer, Forces of repulsion and attraction, Magnetism, Acids and bases in the home, Use of apparatus, Materials and other aids in the study of biology, Study of variety of animals (invertebrates and vertebrates), Study of variety of plants, Sorting and classifying, Natural resources: plants and animals.
Standard 6 (Grade 8)	Electricity, Properties and classification of matter, Particle model of matter, Oxygen, hydrogen and carbon dioxide, Use of apparatus, materials and other aids in the study of biology, Dependence of plants and animals in the soil, Interdependence of organisms, Adaptation of organisms to their environment, Interaction of people with the environment, Interaction of organisms within a species (social insects)
Standard 7 (Grade 9)	Electricity, Force, work energy and power, Pressure, Chemical change of substances, Light, Use of apparatus, Materials and other aids in the study of biology, The cell, External morphology and functions of the parts of the parts of flowering plants, Sexual reproduction in Angiosperms, Life processes and systems of humans.

BIOLOGY

Standard 8 (Grade 10)	Ecology, The cell, Cell division, Plant tissues, Angiosperm anatomy, Mammalian tissues, Aspects of the anatomy and physiology of humans.
Standard 9 (Grade 11)	A study of viruses and bacteria, A study of some plant types, A study of some invertebrate types, Cell division and genetics, Some aspects of the anatomy and physiology of humans.
Standard 10 (Grade 12)	Biological compounds and nutrients, Enzymes and co-enzymes, Angiosperm physiology, Cellular respiration, Some aspects of human anatomy and physiology and homeostasis, Some aspects of homeostasis in certain animals and humans, Certain aspects of population dynamics.

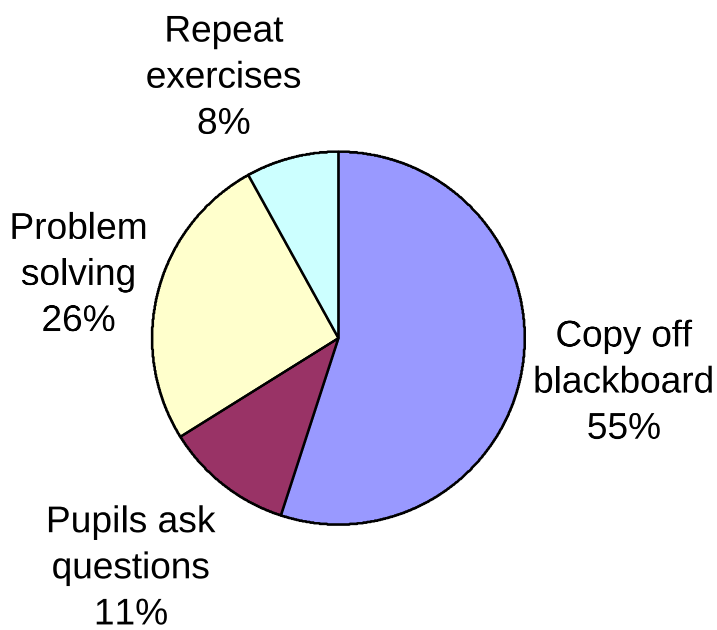
PHYSICAL SCIENCE

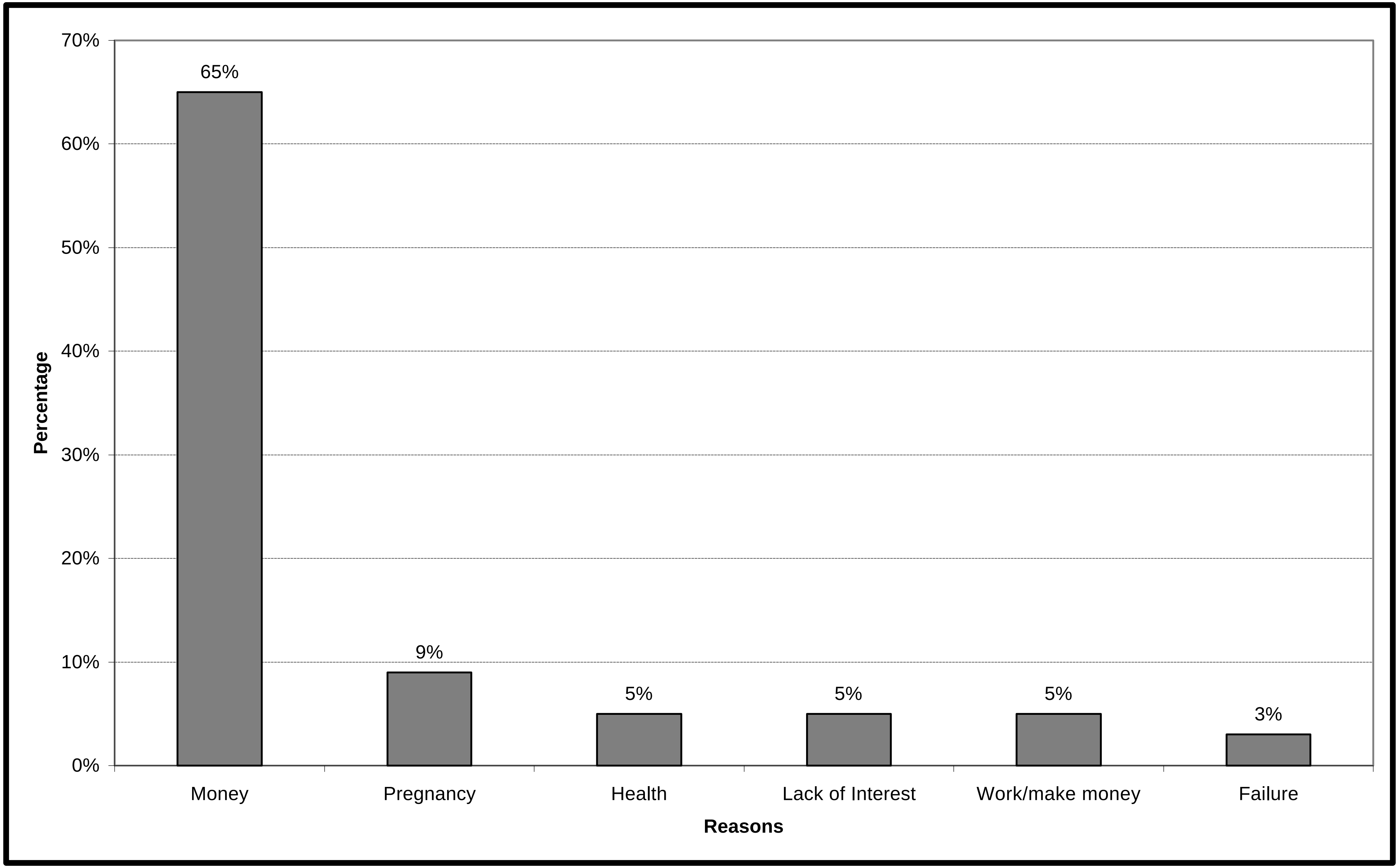
Standard 8 (Grade 10)	Waves, light, sound, electricity, Chemical reactions of certain elements, Atomic structure, Acids and bases, Chemical reactions and electricity, Ionic reactions, Heat and work.
Standard 9 (Grade 11)	Vectors, Displacement-time, Velocity-time relationships, Light, The atom, The periodic table, Chemical bonding, The kinetic model of matter and intermolecular forces, Inorganic chemistry, Optional units.
Standard 10 (Grade 12)	Bodies in motion, Electrostatics, The electric current, Reaction rates and chemical equilibrium, Acids and bases, Oxidation-reduction and electrochemical cells, Organic chemistry.

Appendix VII Main reason for leaving school earlier than planned among out-of-school youth

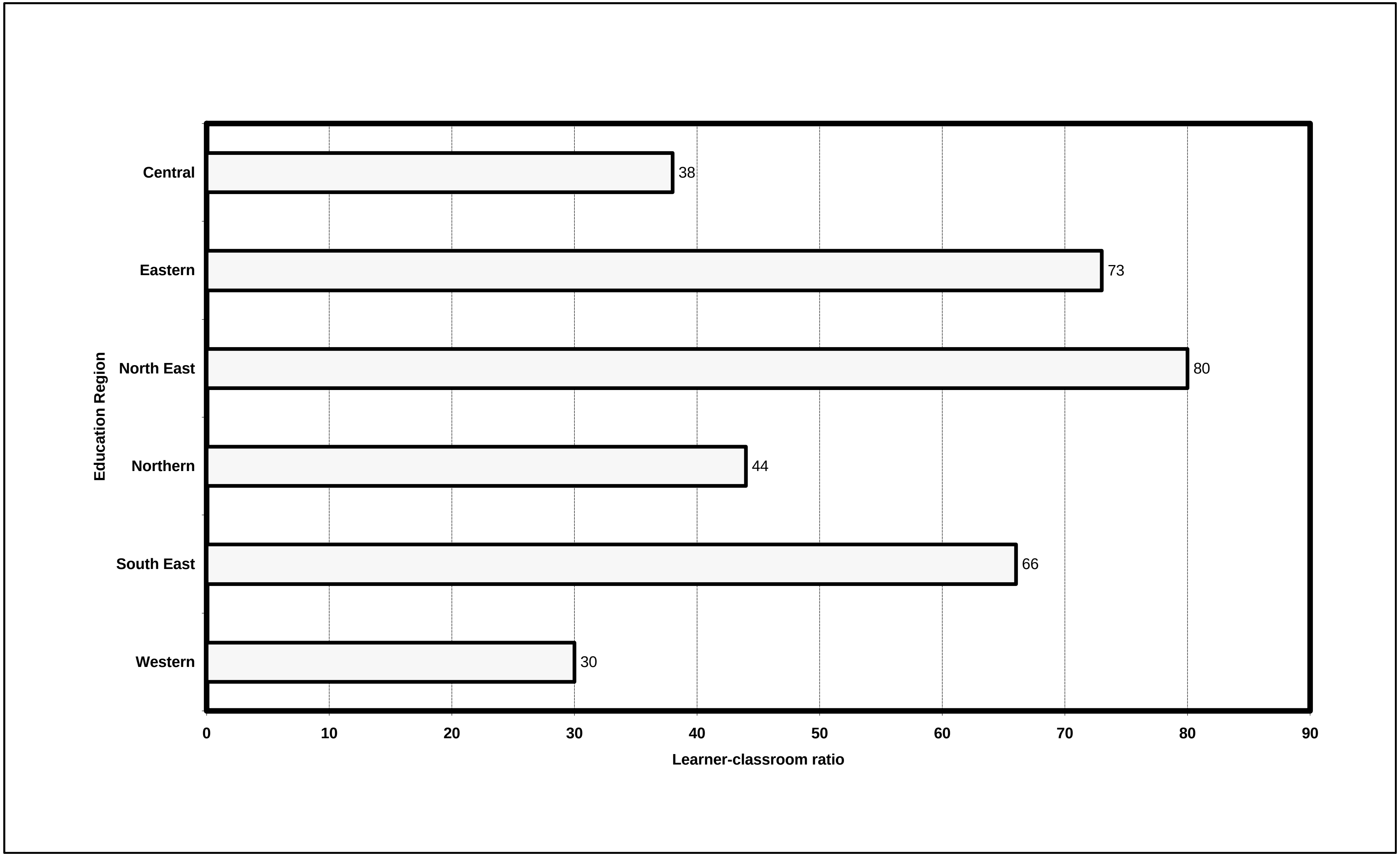
Appendix VI
Main way in which out-of-school youth were taught at school (E. Cape)

Source: CASE

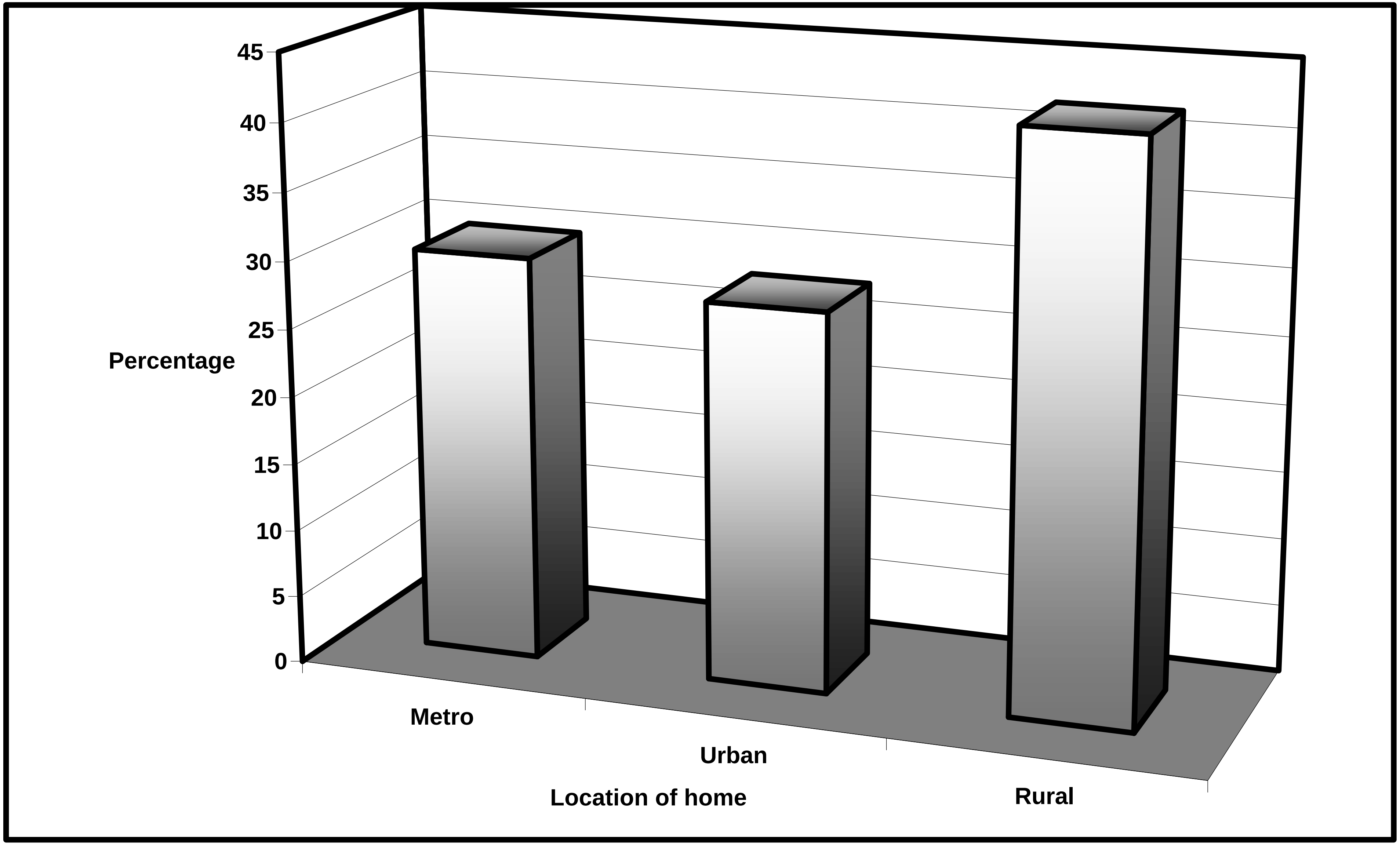



70%
60%
50%
40%
30%
20%
10%
0%
Percentage
65%
9%
5%
5%
5%
3%
Money
Pregnancy
Health
Lack of Interest
Work/make money
Failure
Reasons

Source: C A S E

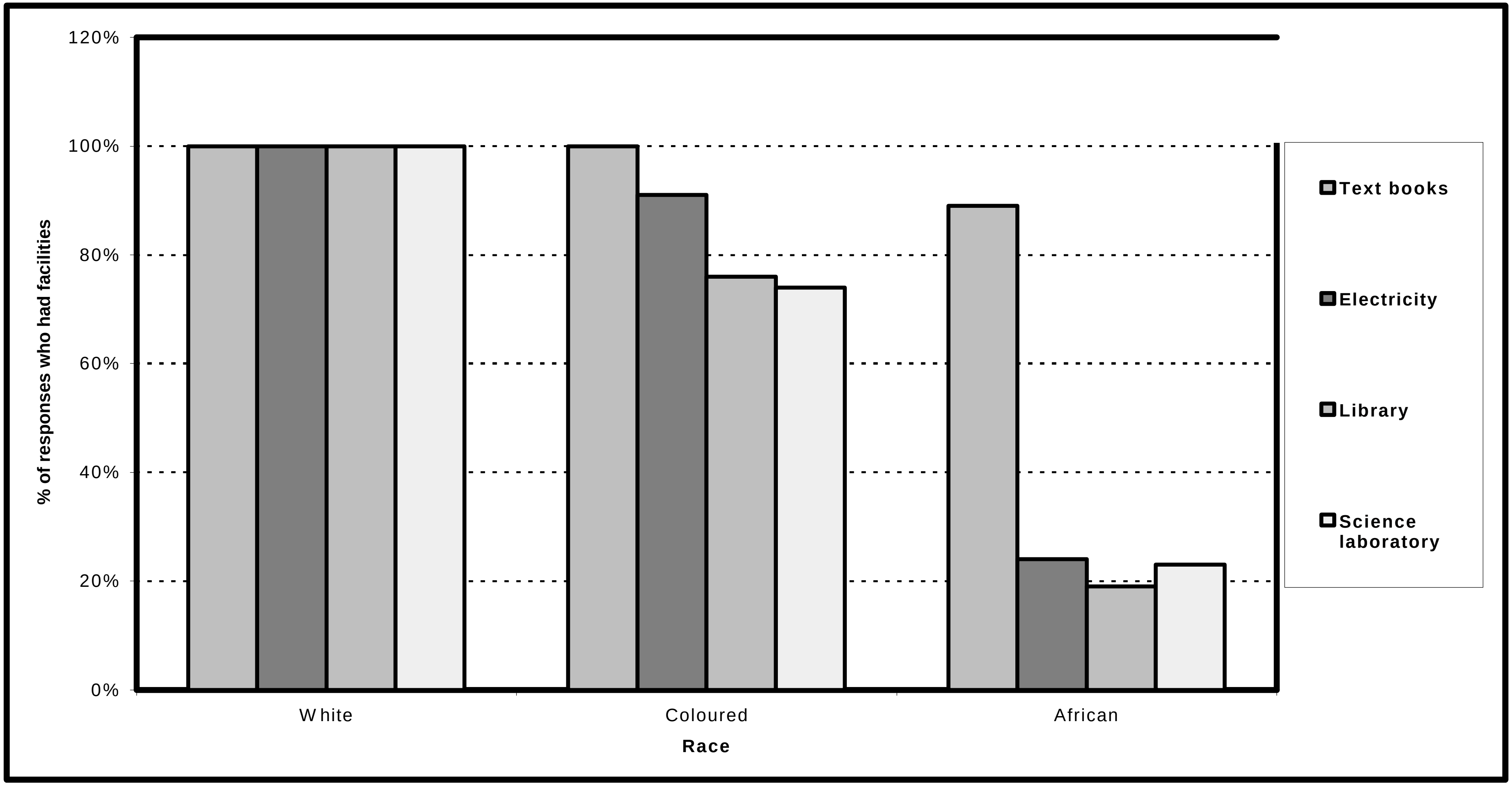

Central
Eastern
North East
Northern
South East
Western
Education Region
38
73
80
44
66
30
0
10
20
30
40
50
60
70
80
90
Learner-classroom ratio

Source: C A S E



Source: C A S E

Source: C A S E



120%
100%
80%
60%
40%
20%
0%
% of responses who had facilities
White
Coloured
African
Race
Text books
Electricity
Library
Science laboratory

Source: C A S E

RESEARCH TOPIC 2

TEACHER LEARNING PROCESSES DURING WORKSHOPS ON ACIDS & BASES

<u>TABLE OF CONTENTS – RESEARCH TOPIC 2</u> **<u>Page</u>**

TABLES

1 INTRODUCTION

1.1 The research problem and context

Learning processes that teachers experience during workshops are often pre-determined. This is because workshop convenors select before the workshop what will be learnt and how it will be learnt. Traditionally hands-on activities are meant to inculcate within teachers the skills necessary for classroom science experiments that are prescribed for each grade. Teachers are taught how to prove established science knowledge.

Hands-on activities are normally based upon a worksheet. Hence Shelton & Hudspeth (1989) (reported in Greene 1993:47) stated that the heart of a workshop lies in a well-prepared worksheet. Worksheets have consequently become part of science instruction although worksheet recipes often do not accommodate divergent approaches.

Recipes may be detrimental to the teacher's professional development since recipes may promote only a few of the wide spectrum of science processes or may in fact inhibit some science processes or processes that teachers may prefer. I draw this view from Johnstone & Letton's (1990) (reported in Doidge & Korving (1998:155) observation that when one follows ‘recipes’, he may have little notion of what he is doing and why he is following the recipe. Related views were held by Roychoudhury & Roth (1996:423) who believed that data could be collected without comprehending meaning of actions taken. As with laboratory exercises, other possible disadvantages of workshops that are structured along worksheets, also mentioned by Roychoudry & Roth as shortcomings of laboratory exercises, include the reduction of cognitive involvement, preclusion of reflective thought, focus on the verification of established laws and principles and focus on the discovery of objectively known facts.

Materials that workshop convenors provide may also influence teacher processes. For example, teachers are likely to 'classify' if they are provided with a variety of materials or to 'measure' if there is measuring equipment. Unfortunately, apart from budgetary constraints that limit provision of materials, organisations that arrange workshops attempt to use those workshops to market their methods and materials. For example, for the teachers to use the Science Education Project (SEP)-designed worksheets, they must understand methods and materials provided by SEP. This is one reason why in my earlier investigations a teacher could not assemble another type of balance but knew how to assemble a balance that was provided with SEP equipment - the teacher lacked the necessary science processes to deal with another kind of balance. It seems that such training based on a selected set of equipment failed to inculcate science processes among teachers. It is possibly due to lack of science processes that teachers yet again have to be trained in the use of Micro Kits made by Somerset Educational.

Worksheet and materials'-based training can negate the teacher's potential to use alternative methods and materials such as those found in their school's environment. This lack of innovation seriously works against the principles of science, and of Outcomes–Based Education (OBE), of localising the curriculum and of developing learning programmes that are locally relevant. Hence, although teachers tend to reflect upon workshops positively in assessment forms at the end of every workshop, many teachers that I visit in their classrooms seem to find problems in implementing the methods that are demonstrated or in using the worksheets that had been introduced in workshops.

The restrictions that teachers find in workshops are a cause of concern since certain processes may not be practised. Hence I thought of removing those restrictions, for example as found in worksheets, to open inquiry using a variety of materials. This open inquiry is similar to that used by Roychoudhury & Roth (1996). That is, the teachers chose approaches freely as they see fit to solve a conceptual problem, construct knowledge, understand a concept, develop methods that they can use in their classrooms and finally be able to reflect on their actions or choices in all these cases. Teachers would also be able to develop their own materials and worksheets that take into consideration the context or environments in which they are being used thus enhancing practicability and relevance of science. It is the processes that the teachers use under the freedom of open inquiry to understand science that I set out to observe.

If successful, open inquiry will be an alternative approach in the way that workshops are conducted. I also hope to use the useful teacher processes to inform concept maps in teacher education courses such as the Further Diploma in Education (FDE).

I focused on acids & bases within the learning context of 'properties and uses of materials as studied in Standard 5(Grade 7)-Senior Phase. Acids, bases and indicators appear in all grades beyond grade 7 and are very common in most environments, in homes and in many industries. Therefore knowledge on acids, bases and indicators is important and applicable in the everyday life of the teachers and their learners.

Teachers had also earlier requested me to teach them about acids & bases during 1997, as a facilitator of the Centre for the Advancement of Science and Mathematics Education (CASME) workshops. I picked on teachers in rural schools where, according to Hartshorne (1992:111), there seems to be neglect. School science does not seem to include life styles in rural areas.

1.2 Survey area

This research was conducted in the north-eastern Region of the Eastern Cape Province, known as Griqualand. Schools were selected by Subject Advisers for science in that region, within approximately a radius of about 50 Km. The First Workshop was held at Tabankulu Primary School and the second workshop was held at the Resource Centre of the Department of Education at Tabankulu.

1.3 Research questions

i. What are teacher’s processes as they try to understand acids & bases?
ii. Do these activities qualify as science processes?

2 SCIENCE PROCESSES

2.1 Assumptions made about science in this research

I assume that science processes define science, although consensus seems to be lacking among educationists on what constitutes science or science processes (methods). I have also assumed that science processes are inherent in hands-on teacher activities during science workshops.

After briefly browsing through science literature, I made the conclusion that there is no consensus on the definitions of science and science processes. This implies that there is probably no universal agreement about approaches in science and science education as well as about the nature of activities during workshops that constitute science.

2.2 Science processes

It is disappointing that not many science textbooks list science methods or processes. I get the impression that authors assume that science processes are implied in the experiments or activities mentioned in those books. It is a pity that not all science textbooks or science courses list these processes explicitly.

A comprehensive list of science processes was given on Web site http://www.sasked.gov.sk.ca/docs/elemsci/menu prs.html (November 1998) as follows:

Classifying - a systematic procedure used to impose order on collections of objects or events.

Communicating – any one of several procedure for transmitting information from one person to another.

Observing & describing – obtaining information about the environment & writing reports or participating in discussion.

Working co-operatively – working productively as a member of a team for the benefit of the team's goals.

Measuring – obtaining a quantitative value associated with some characteristic of an object or event.
Questioning – ability to raise problems or points for investigation.

Using numbers – involves counting or measuring to express ideas, observations, or relationships, often as a complement to use of words.

Hypothesising – stating a tentative generalisation which may be used to explain a relatively large number of events. It is subject to immediate or eventual testing by experiments.

Inferring – explaining an observation in terms of previous experience.
Predicting **–** determining future outcomes on the basis of previous information.

Controlling variables – identifying and managing the conditions that may influence a situation or event.

Interpreting data – finding a pattern in a collection of data. It leads to a generalisation.

Formulating models – representation of objects, events, processes (or ideas).

Problem solving – asking questions concerning the natural world.

Analysing – examining scientific ideas and concepts to determine their essence or meaning.

Designing experiments – planning a series of data-gathering operations, which will provide a basis for testing a hypothesis or answering a question.

Using mathematics – expressing numeric or spatial relationships.

Using time-space relationships – describing the location of things or events.

Consensus making – reaching agreement when a diversity of opinions exist.

In addition to the list above, some books and research papers add, promote or demote some processes. For example, Shulman & Tamir (1973) list (reported in Berg & Giddings - hand out) included arousing and maintaining interest, attitude, satisfaction, open-mindedness and curiosity in science. White (1996:762) included skills in fine movement, and in precision and care. Furthermore, Shulman & Tamir's made some processes to be sub-titles of others, while other authors identify some of the processes above as being more fundamental, and therefore more important, than others. For example, Hodson (1986) believed in the traditional view of the scientific method that science begins with simple, unprejudiced observations.

Therefore the above list of science processes may not be complete and may vary between scientists or between contexts.

3. RESEARCH METHODS

3.1 Introduction

I had preferred to use Action Research because, according to Murray, Olivier & Human (1993:194), Action Research is a problem-solving approach that can inculcate reflective learning, lead to construction of knowledge and can lead to the establishment of individual and social procedures to monitor and improve the nature and quality of knowledge constructions among participants. These views were echoed by Chantler (1996:100), who stated that problem solving helps one towards a more active role in learning, reflecting, organising and creating.

Action Research would be extended to classrooms and would, among other things mentioned by Adler (1993:1) and Chantler (1996:100), develop teachers in their theoretical and practical understanding through critical reflections on their actions, develop their confidence and improve as well as create new teaching strategies as well as materials. In that way a research that involve teachers directly can become a vehicle for curriculum reform, and would therefore be relevant to the current transformation towards Outcomes-Based Education (OBE).

However, a student-lecturer forum at Rhodes University decided that Action Research required more time than was feasible in this research.

3.2 Methodology

This research was approached with some of those aims and methods of Action Research mentioned above. For example, among other science processes mentioned above I aimed at observing how teachers investigate and solve problems concerning their conceptual understanding and teaching of acids, bases and indicators in their local environments.

I used an open inquiry approach whereby each teacher had an opportunity to propose and investigate methods of identifying acids & bases that he felt were appropriate. During this inquiry, further problems arose that prompted teachers to use other science processes. This open inquiry was similar to the approach used by Roychoudry & Roth (1996:425) in that teachers were in control of what to investigate, how to design the investigation, what materials to use and what resources to consult, within the acids & bases topic. Teachers were also free to choose to work individually or to work in groups, and to choose their partners if they were to work in groups. Group dynamics arose as processes rather than as imposed constraints.

3.2.1 The research process

An application for permission to conduct research in Queenstown Region was made to the Permanent Secretary of the Department of Education of the Eastern Cape Province. Subject Advisers then selected the teachers that participated in the research.

3.2.2 The sample

The Subject Advisers selected Standard 5 (Grade 7) science teachers in 10 schools around Tabankulu District in the Griqualand Region. Teachers were selected on the basis of their interest and attendance in previous workshops. The Subject Advisers believed that it were such teachers that would benefit from a research workshop. The selection took consideration of the distances that the teachers had to travel to attend the workshops. Minimising teacher's transport and provision of lunch were used as incentives. Each teacher was given 10 Rand and was served lunch during the two research workshops.

8 teachers attended the first workshop and 12 teachers attended the second workshop.

3.2.3 The research procedure

I conducted this research over two workshops, each of which took place from 10 am up to 3:00 p.m. The First workshop happened during the Second Quarter while the Second workshop took place during the Third Quarter of the school calendar of 1998.

3.2.3.1 Schedule of workshop 1

I firstly explained the aim of the workshop to teachers as that of finding out how teachers go about learning and teaching about acids, bases and indicators, and consequently how teachers go through solving problems. I also explained to teachers some of the benefits of research, such as the improvement of their research skills, improvement of their conceptual understanding and the use of research findings in advising other teachers on teaching science.

I then asked teachers to define and reflect upon their understanding of acids, bases and indicators. I also requested teachers to find ways of demonstrating their definitions using the acids, bases and indicators that I provided.

The following were provided:

Acids	Hydrochloric Acid, Sulphuric Acid, Nitric Acid, Hypochlorous Acid and Acetic Acid.
Bases	Ammonium Hydroxide and Sodium Hydroxide

Other chemicals that were commonly assumed to be neutral:

Copper Sulphate, Sodium Chloride and Sodium Nitrate.

Other substances:

A bottle of 'Jik', a bleaching agent.

Indicators	Litmus Papers (blue and pink), Bromothymol Blue, Phenolphthalein, tea leaves (as used in the tea drink), Beet root and carrots.

I arranged a table for laboratory equipment that included droppers, flasks, beakers, gas stoves and test tubes.

Teachers recorded their findings on the chalkboard accompanied by remarks on whether their findings agreed with their expectations or earlier knowledge. I also asked teachers to criticise their definitions in view of the methods that they used to identify acids & bases. For example, is it true that every liquid that tastes sour is an acid? Do changes in colour of the indicators necessarily define acids and bases?

The next problem posed to teachers was how to identify, and teach about, locally available acids, bases and indicators. I asked teachers to take particular consideration of their learner's exposures, environments and life styles. Teachers proposed and then discussed their proposals, tried the proposals practically and further refined the procedures, which were then demonstrated during the workshop. In effect, teachers were researching their own understanding and teaching of acids and bases, using locally available materials.

My participation included advising on procedures, and providing reference books, laboratory acids, bases and indicators. I also observed and recorded what teachers did as they set about their tasks. I was particularly recording teacher's activities that contributed or inhibited their progress towards conceptual understanding and development of appropriate teaching strategies.

I modified the STOS (See table in results) into a Science Workshop Observation Schedule (SWOS), to include as many science processes as possible, such that teachers activities could be classified among the science processes. I recorded the teacher's activities on video and transcribed the video record into a SWOS by viewing it repeatedly.

3.2.3.2 Schedule for Workshop 2

Teachers reported their classroom experiences when they used the methods they had developed during the first workshop. This was supposed to be followed by further discussions about acids, bases and indicators and by improvements in the teaching strategies of these concepts. However, after reporting on their ventures in their classrooms, teachers felt that they had exhausted activities about acids & bases. The second workshop therefore took on other topics.

The second workshop involved Subject Advisers as well, who took over my role as a workshop facilitator. This freedom from facilitating the workshop gave me ample time to observe and record observations. The participation of Subject Advisers as workshop facilitators had the added advantage of providing data on the traditional workshop approaches, although this was not planned initially. The second workshop was also video recorded and results were transcribed into the SWOS.

3.2.3.3 Possible benefits from this research

- Learning the preferred processes of science teachers for future application.
- Exposing teachers to alternative methods of learning or teaching about acids, bases and indicators.
- Teachers discovering other acids, bases and indicators.
- My personal development as researcher and workshop convenor.
- Trying out open inquiry as an alternative approach in workshops, lectures and classrooms.

3.3 Research paradigm

This method of research was within the social constructivism paradigm because, according to Bussi (1991), social constructivism constitutes debate and construction of knowledge through shared activities. Furthermore, the research procedures created room for contributions and experiences of each teacher.

The method was also post-modern because there were opportunities to teachers to reflect upon, contexualise and reorganise their conceptual understanding and methods of teaching science. It also offered possibilities for transforming learning and teaching practices towards OBE. The research procedure could be an ongoing process by which every step is reflected upon and researched again for further improvement.

4. RESULTS -

TABLES OF RESULTS: A SCIENCE WORKSHOP OBSERVATION SCHEDULE (SWOS) (Modified from STOS)
(Observations for all groups were combined in one table.)

Table 1 SWOS for Workshop 1

TEACHER ACTIVITY	SEQUENCE OF EVENTS - 10 - MINUTE INTERVALS (Lunch break at the end of workshop)																								REMARKS
Time in minutes	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*	*110*	*120*	*130*	*140*	*150*	*160*	*170*	*180*	*190*	*200*	*210*	*220*	*230*	*240*	*250*	
1. **Classifying**							✓	✓	✓	✓	✓	✓	✓	✓	✓											***All these processes happened at the same time***
2. **Communicating**							✓	✓	✓	✓	✓	✓	✓	✓	✓											
3. **Observing & describing**							✓	✓	✓	✓	✓	✓	✓	✓	✓											
4. **Working co-operatively**							✓	✓	✓	✓	✓	✓	✓	✓	✓											
5. **Measuring.**																										
6. Do teachers **question** definitions /facts? Are questions open / closed?													✓	✓	✓	✓	✓						✓	✓		After the inconsistency of colour changes
7. What is done about ideas? -Are they **questioned?** -Are they modified?																										There appeared to be a fear of interrogating ideas of other people, perhaps out of respect.
8. Do teachers entertain each other's ideas? -How?							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		Teachers supported each other but never criticised each other.
9. Is an idea followed through to a useful **conclusion**?																										There was lack of critical analysis of ideas.
10. Daily-life context/influence or **relevance** of the practical? -Is this mentioned?																					✓	✓				Few cases when teachers tried to relate colour changes due to pH to colour changes in fruits.
11. Teachers **initiating** activities							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							All practical activities.
12. **Hypothesising**									✓	✓	✓	✓	✓	✓							✓	✓				Yes, on colour changes.
13. **Inferring**									✓	✓	✓	✓	✓	✓	✓	✓	✓									Yes, on colour changes.
14. **Controlling variables**											✓	✓														Concentrations.
15. **Using numbers**																										
16. **Interpreting data**											✓	✓	✓	✓	✓	✓	✓	✓	✓							Colour changes.

17. **Formulating models**																										
18. **Problem solving**											✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						How to extract dyes from flowers.
19. **Analysing**																				✓	✓	✓				Data in table.
20. **Designing experiments**										✓	✓	✓	✓	✓	✓	✓										When testing unknown substances.
21. **Using mathematics**																										
22. **using time-space relationships**																										
23. **Consensus making**							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				Consensus was almost a cultural more than a scientific process.

***Table* 2 ST0S *for* Workshop 2. (Conducted *by* Subject Advisers)**

TEACHER ACTIVITY	**SEQUENCE OF EVENTS - 10 - MINUTE INTERVALS (Lunch break at the end of workshop)**																									**REMARKS**
Time in minutes	***10***	***20***	***30***	***40***	***50***	***60***	***70***	***80***	***90***	***100***	***110***	***120***	***130***	***140***	***150***	***160***	***170***	***180***	***190***	***200***	***210***	***220***	***230***	***240***	***250***	
							Subject Advisers took over the running of the workshop.																			
1. **Classifying**																										
2. **Communicating**				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓											Reporting classroom experiences with acids, bases & indicators.
3. **Observing & describing**																				✓	✓	✓	✓			Some experiments.
4. **Working co-operatively**																						✓	✓			Measuring distances of gas diffusion.
5. **Measuring.**																										
6. Do teachers **question** definitions /facts? Are questions open / closed?																										
7. What is done about ideas? -Are they **questioned? -**Are they modified?																										
8. Do teachers entertain each other's ideas? -How?																				✓	✓	✓				In case of unexplained phenomenon.

9. Is an idea followed through to a useful **conclusion**?																										
10. Daily-life context/influence or **relevance** of activity. Is this mentioned?																										
11. Teachers **initiating** activities																										
12. **Hypothesising**																										
13. **Inferring**																										
14. **Controlling variables**																										
15. **Using numbers**																										
16. **Interpreting data**																			✓	✓	✓					
17. **Formulating models**																										
18. **Problem solving**																	✓	✓								
19. **Analysing**																	✓	✓	✓							
20. **Designing experiments**																										
21. **Using mathematics**																										
22. **using time-space relationships**																										
23. **Consensus making**																		✓	✓	✓	✓	✓				

The Subject Advisers did not like the pace and style of Workshop 1. They said that very little content had been covered and that time was wasted during Workshop 1. When the Subject Advisers took over the running of Workshop 2, they conducted the workshop with the traditional lecture approach with demonstrations and teachers repeating some of those demonstrations. It appears that the approach used by the Subject Advisers did not stimulate teachers to practice most of the science processes (Table 2) as much as the open inquiry approach that was used during Workshop 1.

Results from Workshop 1 are tabulated in Table 1 and results from Workshop 2 are tabulated in table 2 above. Teachers were active for most of the workshops but it was difficult to categorise teacher activities into science processes listed in the SWOS. The SWOS could only be confidently used after repeatedly viewing the video record. In practice it was difficult to fill in the SWOS while attending to teachers and while observing the teacher activities.

During Workshop 2, teachers reported about their experiences using the open inquiry approach. Teacher reports concerning their class experiences with acids, bases and indicators using the open inquiry approach varied from complete exuberant experiences to cases of having had no chance to practice 'acids & bases' in class.

Out of the 8 teachers that attended Workshop 1

2 teachers gave positive reports that open inquiry was successful in their classes.

3 teachers did not give exciting reports, saying that learners were confused,

1 was late for Workshop 2 but briefly said they had no equipment and materials and so could not teach about acids, bases & indicators.

2 were absent from Workshop 2.

Therefore of the 12 teachers that attended Workshop 2, 6 had not attended workshop 1.

4.1 Understanding of acids, bases and indicators

Teachers were proud of being able to explain their understanding of a concept, especially when they were sure of the 'correct' explanation. Teachers recited what they knew already as if they wanted to gain acknowledgements from their colleagues and Subject Advisers. Each teacher thus taught others what he knew best. Much time was spent on each teacher trying to propose to study a concept that he understood most. This observation supports Lubben & Campbell's (1996:319) view that interest is increased by contexts in which learners perceive themselves as 'experts'.

Unfortunately, many recitations revealed flaws in the teacher’s conceptual understanding. For example, the balancing of chemical equations was a mechanical process of simply counting similar symbols on either side of the chemical equation. Teachers reasoned that each of these symbols must be equal in number on either side of the equation but were not able to explain the process and the laws involved in chemical reactions that are applied in balancing those chemical equations.

There were problems in demonstrating the definitions - for example, many teachers defined an acid as a substance that turns litmus paper red. Yet the change of litmus caused by acids varied between pink and pink-blue. Teachers were not able to demonstrate the definition that acids donate hydrogen ions. Teachers concluded that there was no use in a definition that can not be demonstrated to learners. Teachers were surprised to find that salts such as Sodium Carbonate were not neutral.

All teachers participated in discussions about colour - there were lively debates around naming colours, particularly because names of most of the colours were not known. Nor did these colours have names in vernacular. Similarly most of the flowering plants were declared to be exotic by the teachers and so could not be named. Particular problems were experienced with shades of the same colour. For example, there were many shades of red that could not be named. Besides, colours differed due to concentrations, especially because there was no way of preparing known concentrations of indicators extracted from flowers. Teachers consequently realised that the concentration of an indicator can have an effect upon the appearance of the colours.

Teachers found that the changes of flower colours were unpredictable. For example, not all red-coloured flowers turned yellow in acids. This meant that colour change on its own was not reliable as an identification of acids or bases without the knowledge of the plant species from which the flower was obtained.

I informed them that it was not easy to measure the pH or determine the pH at which colours changed. Thus it would not be easy to use flower colours to identify substances as acids or bases, since a colour change could happen for example at pH = 9.

4.2 Teacher activities

After suggesting to teachers that natural colours as found in flowers could be used to identify acids and bases, silence followed after which lively discussions took place.

Teachers decided to extract colours from everything around, such as the flowers, beetroot, carrots, tea and paint.

Teachers had to grapple with methods of extracting colours from the flowers. They initially put the whole flower in acids or bases and got no colour changes. I had to remind them that often the colours in flowers are enclosed in organelles in cells whose walls can not easily be penetrated by chemicals. Hence they decided to grind flowers in water, again discovering that not much colour came out of the flowers. They eventually found that boiling flowers, grinding the flowers in the hot water and then filtering off the solution was the best way of extracting colours from the flowers.

They put colours from flowers of six different plant species into six different test tubes. Teachers decided to start by putting a drop of each one of the six flower colour into a sample of a known acids such as Sulphuric acid and a known base such as Ammonium Hydroxide so as to establish colour changes of each flower colour when put in an acid or a base. Then other substances were classified on the basis of how similar their effect upon flower dyes were with known acids and bases. Thereafter, teachers decided to try acids and bases on all available coloured substances such as tea, coffee, beet root, carrots and even scraped some red paint off a building.

The discovery that natural colours found in flowers can be used as pH indicators was very exciting to teachers and resulted in lively debates. They drew the conclusion that coloured substances are affected by pH. Teachers discovered other natural indicators - in fact they discovered that most natural colours were found to respond to a change in pH, a discovery that teachers were able to link to colour changes in plants. For example, teachers were able to correctly hypothesise that colour changes in fruits could be linked with pH changes during the maturing processes in those fruits.

The discussion about colour changes in fruits led to that about bleaches such as 'Jik'. The problem with 'Jik' was that it turned every colour white. This was one instance when the transfer of hydrogen ions in protolytic reactions, and therefore the definition of acids as donors of hydrogen ions could be introduced. However, this was still abstract in that the ions were not visible - the explanation apparently caused some confusion and nearly derailed the lively activities. Similarly the fading of colour in clothes that are continuously exposed to sunlight could not easily be explained. I had to steer the workshop back to more concrete activities.

Teachers drew the following table on the chalkboard to record their findings:

Table 3 Some of the results that teachers obtained during the Workshop 1

Flower Original Colour	Colour in Water	Colour in Sulphuric Acid	Colour in Ammonium Hydroxide	Colour in unknown substance A	Colour in unknown substance B	Colour in 'Stoney'
1- Reddish	*Pink*	*Yellow*	*Colourless*	*Cream*	*Yellow*	*Cream*
2- Reddish	*Maroon*	*Red*	*Green*	*Blue-Green*	*Pink*	*Red*
3- Yellowish	*Cream*	*Red*	*Blue*	*Blue*	*Pink*	*Pink*
4- Whitish	*Colourless*	*Pink*	*Colourless*	*Colourless*	*Pink*	*Pink*
5- Cream	*Colourless*	*Red*	*Colourless*	*Colourless*	*Pink*	*Pink*

Deductions that teachers made from the table above:

Substance A was basic - (it was in fact a dilute solution of Sodium Hydroxide)

Substance B was acidic - (it was in fact a dilute solution of Orange Juice)

'Stoney' was acidic - 'Stoney' contains ginger.

In another instance, a teacher suggested to mix an acid and a base. He mixed Sulphuric Acid and Ammonium Hydroxide. Other teachers kept a distance predicting fire or an explosion. Although there was no fire or explosion, teachers found that the mixture was hot. Again teachers predicted that the mixture was neutral. Teachers found that the mixture was basic. No teacher could suggest that concentrations could play a role although all agreed that quantities of the reactants played a role in determining the final pH. Many other common substances, mostly soft drinks were tested and found to be acidic. It was in fact difficult to find natural bases.

Teachers enjoyed to work freely and to demonstrate that they can carry out investigations by themselves. Table 1 & 2 show that there were more teacher activities during Workshop 1 when teachers had the opportunity of the freedom of expression and choice of activities than during Workshop 2 when Subject Advisers lead them through experiments. Thus traditional workshop approaches probably restrict teachers’ activities.

It is important to point out that no one process could be isolated from others at any one time. For example, observations were accompanied with communication by which different views and observations were shared. The processes seemed to compliment each other and had to happen at the same time.

In agreement with Hodson (1986), the most popular process was that of observation. Other processes followed observation. For example, teachers naturally recorded their findings and sought consensus on their observation, especially with regard to colour, since many colour were difficult to describe. Unfortunately, many teachers were not confident enough to express their views or observations.

The open inquiry approach unfortunately did not offer support to shy or unconfident teachers. It appeared as though groups offered security to those who were not self-confident. There was no mechanism by which none confident teachers would be "forced' to give their views. Teachers had a tendency of making similar records in their notebooks after a consensus, (which were eventually recorded on the chalkboard); thus dominant characters in the groups easily subdued views of individuals that were shy. Holding a radically different view was seen as rebellious, particularly against the dominant characters, who were mostly males or elderly females, who would follow up on to oppose the divergent view. The respect accorded to age was also apparent within groups. Thus 'consensus' was not fully democratic since it was more of the dominant teachers giving their views or observations to the rest of the group than a thorough discussion of the various opinions.

It was also interesting to note that teachers formed two groups without being asked to do so. The number of teachers in a group was not fixed as some members shifted between groups to observe an interesting result in either group. The number of available equipment also dictated the number of groups, apart from other factors. For example, there were only two gas stoves. Secondly, there appeared to be a tendency of the less confident teachers congregating around those who gave the impression of knowing what to do, although there were no distribution of roles - some quiet agreement seemed to exist on the distribution of roles. The exception was the washing of equipment, which was done solely by female teachers.

Group leaders were not appointed but assumed these roles on the basis of how much they seemed to know. Thus, leadership could temporarily shift to a member in a group who knew what to do and how to do it. There were a few cases when two members would temporarily isolate themselves to repeat an activity or experiment on an aspect that the rest of the group was not interested in.

There were constant consultations with me, books and between groups. Teachers came to me for clarification when their findings differed from records in their textbooks. Teachers gave the impression that they doubted their procedures or methods when their observation differed from textbook records. They repeated the experiments when their observations differed between groups or differed from textbook records. There appeared to be some doubt of my views that were radically different from textbook information too.

The following processes were mostly practised:

Classifying - acids were separated from bases. Flowers were also grouped into those that respond to acids or to bases.

Communicating - teachers transmitted findings between themselves.

Observing &describing - this was perhaps the most abundant activity as teachers tried to describe colour changes.

Working co-operatively - Teachers worked together in and between groups.

Questioning - Questioning among teachers and between teachers and myself, about how to, for example, extract colour from the flowers, were frequent.

Hypothesising - teachers hypothesised that any colour can be used as a pH indicator.

Inferring - teachers were able to explain colour changes in terms of their experiences with traditional pH indicators.

Predicting - predictions on colour changes were made whenever another flower species was used.

Interpreting data - colour changes were generalised in terms of acids and bases.

Problem solving - teachers solved problems that were obstacles in the course of their investigations. For example, teachers found a way of extracting colour from flowers. Teachers also tried to find a better way of teaching about acids and bases.

Analysing - the definitions of acids, bases and indicators were reviewed. Teachers rejected the definitions that were not practicable or definitions that could not be demonstrated. For example, teachers said that defining acids and bases in terms of the transfer of Hydrogen Ions was abstract and could not be demonstrated to learners.

Designing experiments - teachers designed activities to identify acids and bases. They also designed methods of extracting dyes from flowers.

Consensus making - teachers sought consensus during observations and when data was being recorded on the chalkboard.

4.3 Conclusion

Teacher processes were consistent with most of the science processes as presented by the Web Site above, although I think that my judgement is subjective to my understanding of science processes and their demonstration as well as to context. The teaching or learning about acids, bases and indicators were successfully contexualised in a rural setting with the open inquiry approach. With an open inquiry approach, "objectives' or 'outcomes' seem to come naturally in course of activities. Open inquiry also created a community learners that similar to that described by Roychoudry &Roth (1996:441).

5. DISCUSSION

5.1 Methods and instruments

This data can not be generalised because it dealt with a very insignificant proportion of the science teachers. There is a need to replicate the research exercise in urban areas, with teachers of other grades and with other science content in order to develop a hypothesis regarding open inquiry. Besides I am not sure of the qualifications, experiences before this research and opinions of the teachers that participated in this research. However, there were observations that lead to interesting speculations about the possibilities of using open inquiry.

The open inquiry approach can go a long way in encouraging teachers to take responsibility for their learning for developing teaching strategies and materials. Activities during the open inquiry workshop were more open-ended and accommodated a wider variety of experiences, knowledge, questions and approaches. The open inquiry approach exposed teachers to what Nott (1996:816) referred to as the 'messy open-ended investigations in science education'. The problems encountered during open inquiry are beneficial in developing the teacher's concept of science and science methods. For example, the knowledge that all experiments do not end up in a 'right answer' is important in that teachers can start accepting results obtained by their learners even if such results do not agree with textbook accounts. By facilitating workshops with an open-inquiry approach, teachers had the freedom to research their conceptual understanding of content and teaching methods. Open inquiry can also be compatible with a variety of cultural values and approaches.

Another aspect, albeit a negative one, is that other people may not accept the findings as useful knowledge because this open inquiry did not follow approved methods of research. Nott (1996:816) pointed out that the social structure of science does not allow anyone to make a knowledge claim unless it has roots in a research school or paradigm. To understand the dilemma that teacher researchers can face, one needs to place himself in their boots.

> I am invited by my Subject Adviser to attend a workshop. The convenor introduces a new approach by which I get results that somehow differ from textbook knowledge. The Subject Advisers use the traditional approach in the following workshop. I would feel insecure in the eyes of the Subject Advisers who might be responsible for my promotion if I opt for the open inquiry at school. Besides

> who else of authority will acknowledge my development in research skills or would learners and parents accept these new approaches?

The inhibition of Subject Advisers against practising open inquiry during Workshop 2 with teachers could have been similar to that described by Denny (1986:335) between teachers and learners. Denny said that teachers may be inhibited from encouraging divergence, open-endedness and genuine discovery amongst their pupils (for genuine discovery can lead to discovering what is not expected), when very soon afterwards the pupils are expected to adjust to a highly directed learning style required by closely prescribed examination syllabuses.

Therefore there is a likelihood that although teachers enjoyed the open inquiry and some reported positively about its application in their classrooms, they may not apply it seriously in their classrooms or request for it in subsequent workshops. After all I can not be sure of their reports - a visit to their classes would have helped towards substantiating their claims.

Findings and skills that are radically different from tradition may be resisted, since, as Nott (1996:817) put it, pupils and teachers are constrained by the accepted canon of knowledge. Open inquiry as an alternative will therefore require the involvement of education authorities apart from all other educationists, parents and learners. I will also have to give the findings from this research to the Director of CASME to allow me to use open inquiry in subsequent workshops.

Open inquiry requires some direction in form of an initial push and knowledge that will motivate further inquiry. It can also become an endless exercise that can make teachers lose their focus on the more important aspects of science. The convenor has to be well informed about the topic that is being covered during the workshop because teachers can produce results for which the convenor has no answers. While the convenor's acknowledgement that he does not know all the answers just like the teachers can inculcate confidence in the teachers, it can also create a lack of confidence in the convenor especially if many of the results can not be explained. It is also important that teachers become aware that many phenomena can not be explained by current science knowledge.

The science processes listed in SWOS were preconceived notions of science that could have instead acted as a smoke screen behind which there could be other important processes. The definition of science should be clarified before a critical judgement of the suitability of the methods and instruments used in this research can be made.

The use of the SWOS in this research demonstrated the versatility of the STOS, especially if it is accompanied with video recording. The STOS is versatile since it can be modified to suit the research questions. The video record is a very important tool as the researcher can revisit the research activity. The video can also be replayed for the participants at a later date so that they can criticise their approaches. However, the need for second person can not be over emphasised.

5.2 Discussion about the research questions

Research question 1

What are teachers' processes as they try to understand acids & bases?

Research question 2

Do these activities qualify as science processes?

The teachers were active throughout Workshop 1 (open inquiry), and went through processes that qualified as science processes as listed above (page 82). It was interesting to note that many processes could be integrated in an activity. For example, while boiling flowers, discussions, hypotheses and inferences were also taking place. None of these came before or after the other and I can not comfortably say that all teachers started or ended with any one process.

The implication of this observation is that a convenor of a workshop or a facilitator of a learning exercise can not plan for a single process in isolation and can not sequence processes. Facilitators can however make sure that they create an environment and atmosphere that motivates learners to exercise science processes. Such an environment ought to have as much materials and equipment as possible.

In terms of OBE, it could be futile to pre-set Outcomes (or processes) that one intends to achieve during a planned workshop.). We can perhaps pre-determine the content around which processes can be practised – like in the case of Workshop 1, during which the content was about acids & bases.

It is debatable whether some processes are more important than others are and should therefore be mentioned or planned for. My experience of Workshop 1 was that all processes form a body of knowledge that is interconnected Each one process is like a link in A physical structure which, if removed, can make the structure to collapse. For example, hypothesising goes in hand with inferring and with discussions. Perhaps it is enough to let activities continue but to highlight some aspects of the science processes.

It is more important for teachers to learn and practice the science processes than memorise content. This is because they can apply the processes to acquire and apply knowledge in so many other contexts if they have knowledge of science processes. The situation where teachers know how to use only a few types of equipment can be avoided if workshops use the open inquiry approach.

I have noted with interest that statements of outcomes in Natural Sciences are consistent with science processes. In fact Specific Outcome 1 recommends the use of science processes thus 'Use process skills to investigate phenomena related to Natural Sciences'. The teachers did that during Workshop 1 and therefore practised OBE. Other Specific Outcomes were also realised such as Specific Outcome 2, 'Apply scientific knowledge and skills to problems in innovative ways', when teachers extracted colours from flowers and proceeded to use them for testing pH. Similarly many of the proposed Learning Experiences and Performance Indicators could be realised during Workshop 1. Therefore, by the open inquiry approach, the OBE approach is tenable.

5.3 Knowledge about acids & bases

Definitions that can not be demonstrated in a workshop were problematic and therefore can be problematic in a classroom because these lend themselves to theoretical approaches in teaching science. Worse still schools tend to use watered-down definitions found in tertiary institutions of learning, such as universities. Such watered-down definitions are often accompanied by incomplete explanations, because it is assumed that young learners are not able to comprehend certain concepts. The decisions by curriculum designers regarding what level of difficulty or abstractness should or should not be allowed at any grade seem to require more research.

Acids, bases and indicators are some the concepts by which integration between traditional subjects can be achieved - and therefore fit well into the 'modern' Natural Sciences' learning area. The topic cut across many themes and is also found in many grades. Acids & bases can be a good starting point for learning in Natural Sciences and can therefore be used to demonstrate approaches in OBE. Furthermore, the experiences could have highlighted to teachers the fact that although there could be a gap between practice and theory, science can relate to ordinary things in the environment.

6 CONCLUSION & RECOMMENDATIONS

6.1 Conclusion

The findings have important implications in facilitating workshops. I think that Workshop 1 was successful because;

i) Teachers chose the topic to be dealt with. That acids and bases were the teacher's choice could have made the teachers enthusiastic about the workshop.

ii) The topic was apparently easy and familiar. Acids, bases and flowers appear in the everyday life of every person. This was also the view of Lubben & Campbell (1996:315) who claimed that the degree of participation depends on the degree of familiarity with the context provided. They further stated that learning is stimulated by contexts with which they are perceived to be immediate, or future, personal links. It follows closely also with Kuiper's (1998: 12) comment that learning needs to be contexualised into the learner's familiar environment in order to effectively deal with the learner's ideas.

iii) The freedom to investigate. The open inquiry approach provided a chance for every teacher to experiment on a variety of materials and methods - activities were open-ended. This freedom also led to ownership of activities during the workshop and gave confidence to teachers so that they could debate their activities. The open-inquiry approach accommodated a wide spectrum of processes and seemed to increase the confidence of the teachers. I therefore strongly believe that the results support a change to open inquiry in teacher workshops.

The results highlighted comments made by Dlamini (1990) (reported in Lubben & Campbell 1996) that the problem is not that science is not taught today; but the problem is the way science is taught, where the recalling of facts is more important than applying those facts for scientific deduction of information, and then using that information to explain what happens around us and how that information can be used to benefit us. Changing our focus from objectives to outcomes is indeed a realisation that the knowledge of concepts could be less important than practising processes. In fact some statements of outcomes are processes.

This reminds one of the traditional lesson plans in which objectives were supposed to be explicitly stated. Learning exercises following OBE methods also require statements of outcomes. It is debatable whether it is necessary to state outcomes for a particular workshop or classroom exercise. Or rather how much should a facilitator stick to the stated outcomes? Prescribing outcomes may pre-empt the natural inclination of human beings to follow certain activities when trying to understand a concept. The activities that learners need or prefer to follow may not be in line with the stated outcomes. There is a possibility that each individual uses a different sequence of processes to achieve an outcome, and that some statements of outcomes are stages towards one's conceptualisation of reality. Thus a demand that outcomes expected from a learning exercise must be precisely stated may fall into the same 'objectives ' trap of limiting the exercise to activities outlined in the statement. Interestingly though is the note that laboratory or worksheets for practical work, rarely, if at all, explicitly describe these processes as their main goals.

6.2 Recommendations

i) The definitions of acids and bases are rather abstract and can not easily be demonstrated in a school situation. It is necessary to accept definitions that teachers and learners can practice at their schools. Whether the more abstract definitions should at all be introduced at school level is a question that requires debate. However, knowledge should not be deliberately with held just because it is not practicable.

ii) Open inquiry offers a viable and exciting alternative for teacher workshops. Workshop facilitators should allow teachers do determine their needs and to develop the means by which to achieve those needs however diverse these might be. This recommendation is in agreement with that given by Nott (1996:807) that diversity rather than a single model is preferable.

The disadvantage of open-inquiry approach of taking longer periods can be overcome by limiting the concepts to be dealt with - for example, one can deal with indicators only during one research activity. On the other hand there is no use in hurrying through science activities or concepts when teachers have not understood those concepts and end up with misconceptions.

iii) Rather than cramming many topics of content in syllabi, it may be better to ensure that science processes are developed. With science processes in place teachers can design learning exercises around any topic.

iv) Worksheets are useful as long as they do not limit the natural processes of teachers. In concert with OBE, the open-inquiry approach provides an opportunity to teachers of developing their own learning materials including worksheets.

7 REFLECTION ON THE RESEARCH PROCESS

This was one research activity that the teachers and I really enjoyed. I think that two main reasons made this research exercise interesting;

The fact that we dealt with environmentally common concepts and we dealt with these concepts without following prescriptions, questionnaire or worksheets. Thus not only were the workshops free from control but the research process was not descriptive. Hence there was no feeling that the workshops were indeed research exercises. There is also the possibility that I was more used to researching by the time I carried out this particular research exercise.

This research topic and method was also seriously contested during the student-lecturer forum at Rhodes University. There were sometimes emotional exchanges during the discussion of this research topic. It is because the critical and emotional exchanges that contributed to its success. This led me to think that every idea requires a critical analysis, preferably an opposing debate. I think one is unfortunate if his ideas go unchallenged, for how can we all think the same way? This again reminds me of the moments when our lecturer, Dr. Kuiper, used to comment that he felt let down whenever he introduced knowledge and everyone of us simply agreed with it. In agreement with Dr. Kuiper, I think that a process or knowledge that does not stir up discontent and debate among people is either ordinary or irrelevant and unexciting that participants do not bother to critically think about it. I am happy to note that this particular research proposal caused so much debate and in fact led to further questioning about Action Research that research topic 1 did. I believe that this topic contributed more knowledge to us all.

The aspects that were researched led to more questions than answers, particularly concerning the identification of science processes. I was really concerned that I may have missed some scientific activities by looking for activities that agreed with my list of science activities in the SWOS. It is time that science educators come together to define what constitutes 'science' and 'science education'. Our research methods and instruments are rendered meaningless without a clear definition of science and of science methods.

I am worried that research in science education depends so much on what I take to be science or science processes. My arguments for or against practices in classrooms and workshops are weighed against my definition of science. It appears that there is a need to clearly define 'science processes' precisely in practical terms before a method or instrument can be confidently used to record them. The following questions should be answered:

What constitutes a 'science process'?

Where does science begin and end so that we can start and end to observe for the science processes?

Could there be other aspects of the teacher's behaviour that could be classified as scientific but were not listed in the SWOS?

How are the science processes practised - i.e. What is observation, inferring etc, identified? Did I identify observation correctly? Did teachers understand their activities to be science processes? What is their notion of science? As Olsen, Hewson & Lyons (1996:786) observed, describing approaches is one thing; an understanding of them is, however, rooted for us in the ways in which the teachers view the nature of science.

Answers to these and other questions about the nature of science can change the interpretation of the results that I obtained in this research.

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RESEARCH TOPIC 3

TRANSFORMATION IN SOUTH AFRICA WITH PARTICULAR REFERENCE TO SCIENCE EDUCATION: POSSIBILITIES AND PROBLEMS

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THE TRANSFORMATION OF SCIENCE EDUCATION IN SOUTH AFRICA WITH PARTICULAR REFERENCE TO SCIENCE EDUCATION: POSSIBILITIES AND PROBLEMS

The motivation that lead the author to write about transformation

Through reflections, presentations and research proposals, the Master of Education (Science Education) (MEd) candidates of 1997/98 at Rhodes University claimed to have achieved transformation in their approaches from positivism and modernism to social constructivism and post-modernism. Transformation appears to have been considered as one of the key performance indicators during the MEd. course.

Furthermore, the term transformation has become a buzzword in everyday talk of South Africans, and is topical in political and academic discussions. Yet a simple survey by the author on teacher problems and approaches indicated that there were serious assumptions that have been overlooked in planning for transformation to OBE.

In this essay, the author reflects on transformation, as one of the MEd. candidates mentioned above and on the basis of experiences in science education as a teacher in the Department of Education and field worker with the Centre for Advancement of Science and Mathematics Education (CASME) in the Eastern Cape Province.

Abstract

The term transformation appears to be used loosely and rhetorically. The definition of transformation does not agree with what the actions that are referred to as transformation in South Africa. The history of South Africa indicates that the need to transform arose out of the need to remove apartheid, the Christian National Education (CNE) and Fundamental Pedagogics (FP). Transformation in education has been politicised and in the process has lost track of the main educational issues.

Politicisation has lead to the misrepresentation of the needs in schools. While teachers seek material improvements, they have often dodged critical epistemological discussions on transformation, although the government has focused on transforming the curriculum. This difference in priorities between teachers and government seems to have caused tension and toi-toi of teachers. One can not be sure whether teachers do place their priorities correctly and whether they reflect on their practices.

The problems facing transformation to Outcomes-Based Education (OBE) is that transformation and OBE are both misunderstood, and were introduced into a society that is still mainly pre-occupied with levelling social economic standards between Whites and Blacks. Other problems include language of instruction, multicultural nature of South Africa, lack of funds, lack of well-trained science teachers and lack of apparatus and laboratories.

Transformation to OBE offers possibilities of changing the approaches in teaching science and in making science more relevant in every context.

1. INTRODUCTION: THE NATURE OF TRANSFORMATION

The need to transform candidates in the M.Ed. course was in line with the general trend in education and in every sphere of life in South Africa. However, although the term ‘transformation’ has become a buzzword for academic and political correctness in South Africa, it appears that the process and the results expected of transformation are not explicit or clearly understood. Few documents give a definition and indicators or measurement of transformation. Lack of an accepted definition of transformation is an indication that transformation is not generic or universal and could be beyond objective planning. Consequently, it could be a myth to imagine that South Africans need or talk of the same transformation.

Literature on and analyses of transformation are scarce compared to the frequency with which the term transformation is used in South Africa. In the Oxford dictionary, transformation is defined as a change. However, 'transformation' seems to be preferred instead of the term 'change' when referring to fundamental shifts in paradigms in South Africa.

Behaviour is one aspect in which the term transformation is frequently used. In a behaviourist perspective, a change in behaviour would be synonymous with learning. Thus Ferguson (1982) believed that learning was a transformation that occurs in the brain, whenever new knowledge is integrated or a new skill is mastered. 'Mastering a skill' often has a behaviourist dimension and reminds one of Skinner's operand conditioning by which, not only animals, but human beings learn how to manipulate apparatus through practice and rewards. In a science classroom this would be equivalent to rewarding marks to those learners who can, for example, connect an electric circuit correctly.

However, Ferguson seems to broaden the scope of transformation beyond behaviourist approaches by stating that transformational learning might require a great deal of critical thinking. To Ferguson, a transforming person is an open system that freely interacts with the environment, taking in information interrogating it and using it. It is possibly a similar open system that Doll (1989) referred to as a pre-requisite for transformation. Ferguson also believed that transformation requires an optimum environment, which offers security enough to encourage exploration and effort as well as excitement. This view seems to be in line with the recommendation for freedoms in science education, whereby learners can form their own hypotheses and research them without hindrance, which often encourage learner-centred approaches.

Learner-centred approaches are interpretative in that the learner has an opportunity of deriving meaning from experiences. Interpretativism, particularly as applied to natural sciences, embraces subjectivity and qualitative procedures that are often incompatible with positivism (i.e. objectivity and quantitativity) (Howe, 1992: page not shown on handout). These qualitative procedures applied in teaching and educational research seem to have gained an upper hand over empiricism and rigid statistical models lately (Kuiper 1996).

The description of transformation by Miller & Seller (1985:8) as a meta-orientation goes beyond the personal and focuses upon social change as well. A somewhat similar definition by Sohne (1985) included the holistic opening up and change of heart and mind - a change ultimately directed at a new cosmic, human and religious relationship. At school, these relationships would include teachers, learners and the community at large in a reciprocating relationship. Thus a teacher senses readiness to change in a student and the teacher himself is transformed by the relationship (Ferguson 1982, Sohne 1985).

On the basis of all the views above, transformation and readiness to transformation can be difficult to identify and measure especially because every human being has a subjective interpretation of phenomena - that is, it is difficult to imagine objectivity in transformation. Such objectivity would arrest Doll's open system and contradict abstract processes such as critical thinking. Thus, transformation should be identified in the actions, communication, or behaviour of an individual. It is only when transformation can be identified that a form and scale of measurement can be negotiated with the person that is undergoing transformation. In other words, transformation that is not demonstrated or applied cannot be identified or measured and could be irrelevant. Therefore, outcomes as envisaged in Outcomes-Based Education (OBE) may be essential indicators of transformation.

However, measurement is essentially normative and standardised in society. Therefore attempts to measure transformation may militate against transformation itself. This is because transformation appears to be subjective and because each place and time (or value system) may cause a different kind and rate of transformation. Therefore, the recommendation for continuous assessment in OBE whereby the progress of each individual is measured against itself is in agreement with the definition of transformation. Different individuals experience different transformations, even at the same time and place, such as in the same classroom. Thus it may be futile to measure transformation, especially because the person that is carrying out the measurement may transform also in the process of measuring.

Subjectivity also implies that transformation may mean different things to different cultures, races etc. Therefore, subjectivity makes qualifications such as ‘bad’, ‘good’, 'quick', or ‘irrelevant’ incompatible with transformation because each category of people may have different evaluation systems and beliefs. This implies that there would be no objective criteria of classifying or of identifying transformation for each community in a country. It could be due to this subjectivity that many people, particularly politicians, do not specify the quality or quantity of transformation that they envisage. In which case transformation does not have an end and is perhaps an end in itself and so may not be qualified. However, the absence of such qualifications creates a myth around transformation, that every reference to transformation in a community implies improvements in people's lives. There is no mention of transformation that is harmful to people.

Educationists do not lay out clear criteria for the analysis, identification, or qualification of transformation either; although breaking up the education process into grades, planning objectives in lessons or providing standard apparatus and practical exercises in science implies that educationists can objectively identify stages in transformation. Such objective identification is assumed to prevent irrelevant, bad or wrong transformations and identifies the desired direction for transformation in education. However, planning transformation objectively upon laid out criteria and proving that transformation is taking place probably limit the freedom of, and interfere with transformation of individuals because according to Doll (1989: 246), transformation should operate in an open system.

It appears that transformation is characteristic of life and therefore of culture and may unconsciously take place in a human being. According Piaget (1971: 26) (quoted in Doll, 1989: 246), 'life is essentially autoregulation'. From Piaget's view, it seems that the human body and mind has to transform naturally as a matter of course in the process of development and survival, since the environment, both internal and external, is always changing such that it demands continuous human adjustments. Piaget focused much attention to internal, autocatalytic transformations that Doll (1989: 246) believed should form the basis of curriculum design. Doll further believed that such internal transformations are encouraged in open systems rather than in the present closed-systems format in which transformations are factored out. Modernist closed systems may interfere with the natural inclination of a person to transform. Such interference might include practical work in science that is of no immediate use to the learners.

In practice, transformation may need to follow much of the recommendations outlined by Etchberger & Shaw's (1992:412). Etchberger & Shaw reported Tobin & Jakubowski (no date) who suggested six interrelated requisites necessary for change to occur. These requisites were also similar to those given by Prawat (1992) and are as follows:

1. Perturbation. This is a dissatisfaction or uneasiness with the way things are, e.g., teachers may not be happy with their present teaching methods or satisfied with their student's understanding;
2. Awareness of a need to change. This occurs when the teacher realises that for things to improve there will have to be a change;
3. Commitment to change. When a teacher commits to change, he or she has made a firm decision to move beyond awareness and into action;
4. Vision. With the decision to change, the teacher envisions what the change actually will involve, e.g., arranging desks from six rows of four students to six groups of four students;
5. Projection into that vision. This occurs when the teacher visualises self and class becoming participants in the change; and
6. The resultant cognitive and overt changes involve actual physical and mental processes engaged in making the vision reality.

In conclusion, although the nature of transformation is not very clear, OBE seems to borrow some of its aspects that were identified by Ferguson, Doll, Sohne, Miller & Seller, Howe and Piaget in the above passage. Whether and how transformation is practicable, are questions that require critical analyses of the past and current South African society and education systems.

2. SOME SOCIAL-POLITICAL ASPECTS OF TRANSFORMATION THAT HAVE INFLUENCED TRANSFORMATION IN EDUCATION IN SOUTH AFRICA.

An overview of society and politics in South Africa illuminates the origins of the desire for transformation in education. The overview can also show some of the possibilities for transformation and problems that transformation can face in South Africa. A considerable proportion of this chapter is based upon the author's teaching experiences and observations.

Major shifts in education are decided upon politically to serve popular social interests. Thus, education involves the transmission of values of society (Luthuli, 1985). The continuous change of values and culture is reflected in the transformation of education, which is often achieved via political mechanisms. For example, both the Christian National Education (CNE) and OBE were politically motivated.

In South African politics, particularly in the predominantly Black political movements, the term 'transformation' has been politically used to cover all forms and contexts of education. Furthermore, 'transformation' and political correctness seem to complement each other. Transformation has come with political jargon such as 'mind set', 'transformation', 'people on the ground', 'stakeholders', 'structures', 'paradigm shift', etc. In most cases however, such jargon is vaguely explained although it is assumed that it is understood by the politically correct.

South Africa has experienced political transformation, from kingdoms and chiefdoms to colonialism, apartheid and liberation to democracy. Each of these systems engineered society through education for political gains. For example, in many tribes, certain knowledge was a privilege of the noble who were destined to become leaders. Curricula in missionary institutions required students to become Christians and also to embrace Eurocentric values in place of traditional values. Indeed while traditional beliefs are still taboo in some institutions of learning, Christian and Eurocentric values have hitherto been taken as imperative for an ‘educated’ person.

The assumption that European values are more valuable than Black values, particularly in education, caused far-reaching consequences, lending itself to apartheid by which the CNE and Bantu Education were introduced. European values are perhaps most prevalent in science education in which language and practicals are based upon European values. Furthermore, one can argue that Fundamental Pedagogics (FP) as an approach of teaching was meant to inculcate values that were thought to be desirable by the ruling class - the Europeans or Blacks that had been assimilated into European cultures. Of all social engineering, apartheid's CNE and FP seem to have had the most significant and successful impact, albeit undesirable. Through apartheid education and other agencies such as mass media, Blacks consequently learnt to behave like Europeans. In the process many lost their identity and feel embarrassed by their traditions. In media, Black values are portrayed as out of the ordinary, some being advertised for tourism.

The importation of curricula loaded with foreign values is partly responsible for passive students. Foreign values can not be experienced in the everyday lives of learners and have to be memorised. For example, science education involves a significant proportion of methodologies for which they are no facilities or use in the lives of ordinary citizens of South Africa. In a survey by the author, teachers often complained of lack of apparatus as the cause for not using practical approaches in science lessons. This could be linked to the teacher's perception of science as a foreign construct that has no local use and apparatus.

Looking through science curricula and textbooks one rarely finds records or examples of methods of Black African origin but is confronted with all kinds of examples from the 'First world'. The impression is that Black Africans do not practice science. Aspiring South African scientists are supposed to think or reason like Newton and prove his laws in an environment and society that is so different from that in which Newton developed his laws. Nor are such science laws realistically applicable in an ordinary Black South African school environment, particularly in a rural school. Hence, students have to memorise things like the 'test tube'!

Such approaches served to create a labour market that has kept most Black South Africans subservient in the economy. The under-development of Black areas, particularly rural areas, is partly a result of an education system that has been politically manipulated to produce uncreative school products. In a survey by the author, a teacher could not assemble a simple balance and said that she could not even try. Many teachers seemed to interpret development as urbanisation and knowledge of foreign values as education, and thought that science is found in apparatus and laboratories.

Black South African reacted against such poor education politically because education has been and remains a strong political tool in South Africa. Transformation was necessitated by the restrictive nature of political systems that prescribed roles and education standards and facilities to each category of people and unpopular values through education. Therefore the term 'transformation' was inevitably popularised by political means and its use appears to have increased during the demands for political change in early 1990s.

The desire for transformation gave birth to liberation movements and seem to have increased the sentiments for liberalism in some political organisations, schools and tertiary academic institutions. Liberalism seems to have lead to social liberalism, to toi-toi, affirmative action and a demand for curriculum change - hence OBE. A brief review of liberalism and subsequent developments is necessary for one to evaluate the need, possible success and problems of transformation in the classroom.

According to Smith (1968) (reported in Ashley 1989:29), liberalism is a belief in and a commitment to a set of methods and policies that have as their common aim greater freedom for individual persons. Hence liberalism advocated for democracy that would negate the effects of apartheid. Haralambos (1980:179) held similar views to those of Smith where he stated that liberalism encouraged an individual to develop his mental, physical, emotional and spiritual talents to the full. Liberalism therefore addresses social issues such as self concept and gender equality. For example, females can be transformed from traditional to career roles. Through liberalism, there is freedom of choice, of thinking and of expression at school.

Transformation of individuals can be translated into social economic and political transformation. For individual liberty to develop, education institutions and their teaching methods have to create an environment that is conducive to free debate and choice in line with Doll’s (1989) suggestions of an open system. Classroom approaches need to be transformed from FP autocratic teaching to facilitating free learner inquiry and debate Such a transformation is in concert with the political transformation from apartheid to democracy. The Bill of Rights as pronounced in the constitution prescribes to liberalism and appears to have been one of the approaches towards formulating the new South African Curriculum 2005.

Nevertheless, individual liberty is confined within cultural values and norms that conserve or protect unity, law and order in a society. Hence, individual transformation is subject to community transformation. Thus, according to Ashley (1989:33), the problem for liberals is how pluralism may express itself educationally, without interfering with the freedom of association and individual autonomy, particularly in a multicultural country such as South Africa. There is always a tendency to congregate around some identity such as ethnicity and profession. Apparently, in the author's experience, education fails to undo traditional identities, but causes new ones.

On a national scale, such identities have comprised of races, tribes, religions or academic (professional associations). In South Africa, principles of liberalism and of socialism seem to have been used in the foundation of Black political movements. For example, the Black Consciousness movement that arose from the Azanian manifesto, was an attempt to congregate Blacks against the status quo (Ashley 1989) which held Eurocentric values supreme over those of other races. Blacks have since wished to include their values in South African approaches, often referred to as Afrocentric and probably closely related to the now popularised ‘Ubuntu’ and ‘African Renaissance’. Transformation to include Afrocentricism is liberal, but essentially involves interests or values and norms of whole cultural or social units instead of individuals – it is in other words liberal socialism. Ashley (1989:43) seems to infer that in South Africa liberal socialism emerged more strongly after the 1976 Soweto tragedy during which Black students rejected to be forced to learn Afrikaans.

Liberal socialism, according to Ashley (1989:59) is the outcome of the meeting of socialist and African nationalist traditions (beliefs and values), including Black Consciousness, about education – it appears to have emerged as an active resistance against the CNE and Bantu Education. Ashley continued to say that Liberal Socialism has already a major influence on the development of education in the country through the People’s Education movement. One may argue that it has eventually lead to the transformation of curricula to OBE.

Liberal socialism is in principle democratic and social constructivist such that it would support the involvement of all role players in education such as students, parents and teachers. In the South African OBE, social constructivism caters for the participation of everybody in the formulation of curricula and seems to advocate for group work in the classroom. Liberal socialism may also address science literacy as a social construct, in agreement with Ziman’s (1968 & 1978, reported in Solomon 1994:15) belief that socialisation of knowledge involved frequent reassurances that our understanding makes sense to others.

Furthermore, the transformation perceived by liberal socialists has some elements of Marxism in aiming at the removal of a class-conscious and competition-prone society (e.g., the removal of marks or grades in a classroom). Apparently, liberal socialists seek to transform Blacks from viewing themselves as less valuable, less able or subservient into viewing themselves as free and equal to other races by removing grades that are believed to be based on European values. For example, Blacks should be proud of their culture, environment and skills; these have no classroom-style measurements or grades. Liberal socialists have an important point in that freedom and transformation have to evolve from within culture - possibly transformation has to be part of culture.

Liberal socialism lays so much importance on the ‘majority’. However, Ashley (1989:33) pointed out, that could be to the detriment of individual or minority interests. It can also lead to neo-modernism by which the 'majority' set rules in the name of democracy. For example, a school curriculum is approved by a majority vote in parent-teacher meetings.

Majorities can submerge individual or minority interests and liberties especially when such interests are radically divergent from what the 'majority' holds as the most valuable, the truth and the correct way. Yet, some people do not gain popularity through curricula that are democratically approved. Thus, for example, celebrities like Darwin, Einstein, Bill Gates, Michael Jackson and boxers like Mike Tyson lack academic awards. It is in a similar 'majority' approach that individual talents and interests may find conflict in group work in OBE.

Liberal socialism has tenets of modernism in that it advocates for reasoned debate, inquiry and investigation under approved rules. Modern rules used by liberal socialists seem to differ from, if not contradict rules in many Black cultures. For example, leadership in some cultures is hereditary although liberals would prefer to elect leaders. The conflict between elected leadership and traditional leaders is reflected in the tension between culture and liberal socialism (for example between Chiefs and SANCO). This conflict is akin to that between teachers, whose approaches are autocratic, and learners who want to participate in planning their classroom curriculum.

Pallo Jordan (Mail & Guardian, April 24th-29th, 1998) argued that modernism implicitly challenged the legitimacy of the traditional African aristocracy. He further said that the rationalist bias of modernism includes the interrogation of traditional belief systems, customs and mores. Thus, liberal socialists will probably find more problems in transforming African cultures that are rooted in their traditional patriarchal or aristocratic systems. In many cultures, hierarchy or subordination and economic power keep order. Social or economic patriarchs are characteristic of many homes, political parties, institutions and student organisations. For example, leadership is an admired attribute but essentially involves superiority over subordinate subjects. Children are taught to obey parents, students have to obey teachers and so on. Few African cultures allow children to debate issues openly especially with adults.

The proletariat, and indeed the many people among the ANC political leadership attribute the conflicts and slow pace of transformation in education on the claim that the process of transformation is eroding the privileges of the 'advantaged' or the bourgeoisie - such privileges are often Eurocentric. Paradoxically too, the same leaders in the ANC government that are complaining about the slow pace of transformation seem to opt for European values. For example, their children attend former model C or private schools. Few or none can be found in rural or township schools for which they campaign for urgent transformation. They therefore do the campaigning outside the parents body of those schools. Transformation in such schools is likely to fail because those schools lack parents (and often qualified teachers) with financial, material or academic input that is necessary for successful transformation.

From their life styles, it is a reasonable assumption that many of ANC officials have interpreted transformation as the adoption of life-styles of the 'advantaged' in form of children attending in affluent schools, luxury cars, frequent trips abroad, high salary packages, acquiring more property, jobs and land. Yet, on the basis of Ferguson's (1982) definition of transformation, these material or job acquisitions may not cause transformation since acquisitions may not re-orientate the minds of the beneficiaries.

Events after independence in many other African countries, such as Uganda and Tanzania show that transfer of property and jobs does little towards transforming people's educational, social, political and economic approaches. Such acquisitions are similar to providing apparatus and laboratories to teachers who in the end do not have the skills to use them. OBE will be misinterpreted if the people view it as a process that will lead to material acquisitions.

Transformation that is based upon material acquisitions is difficult to distribute to the majority because it is expensive. Often the 'majority' becomes frustrated with the pace of such transformation and then resort to toi-toi. The cause for toi-toi has included, for example, students in universities demanding larger fee subsidies, and teachers demanding higher salaries and modern apparatus, possibly after teachers and students observed that the leadership had upgraded its social, financial and material positions.

Teachers, students and government all 'demand' transformation. The government for example imposed criteria of transformation in institutions that 'must' reflect the racial composition of South Africa by year 2000 (Television News, 29th April 1998), regardless of institutional values and norms and regardless of individual or community interests. Similarly, the athletics, cricket and rugby teams 'must' include Blacks in their teams although many Blacks seem to prefer soccer and lack the facilities for other sports in their residences and schools. In the classroom, government demands include that science teachers must approach science practically although they lack apparatus and laboratories, and lack skills in using apparatus and organising practical work.

These examples illustrate that the teachers and students as well as the government are all operating with a degree of modernism and cultural or traditional approaches to transformation. One notable difference between government and teacher approaches is only that while the government wants a curriculum change (it has introduced OBE), teachers are still demanding material improvements, perhaps as pre-requisites to teach the way the government demands them to teach and to facilitate OBE.

Conflicts in society, for example between political parties and traditional chiefs, indicate that transformation in South Africa is still at the stage of mutual interrogation between modernism and the traditions. It is thus unlikely that society can transform to post-modernism before it has embraced modernism. OBE faces a dilemma in that it is a post-modern, post-positivist concept that has been politically introduced in a society that is still aspiring to be modernist.

3. TRANSFORMATION IN EDUCATION

3.1 The past approaches in education

One of the main fronts that Europe used to conquer and divide Africa was religion and religious education. For example, South Africans received much education through Christian missionaries of various denominations, which replaced many of the African values. It is interesting to note that Black South Africans suffered the conflict between these religions and politicians that wanted to rule South Africa. For example, Marrow (1989:37) pointed out that the CNE arose out of a political struggle of the Afrikaners who felt threatened by liberalism as well as Anglicisation advocated by mainly the English people of South Africa. Of all curricula, both the CNE and Missionary Education appear to have had the most significant effect in the history of South African education.

Ashley (1989:11) reported that the CNE conceived schooling as a process of 'moulding' children into the image of adult's role models. This fitted well with designing roles for each race. For example, Bantu Education was designed to mould Blacks into subservient citizens in science and science-related fields. The CNE had to use Fundamental Pedagogics (FP) as a method of moulding. Landman, Kilian, Swanepoel and Bedonstein (1982) in expressing the basics of FP emphasised the characteristics and role of the teacher as an exceptional adult, trustworthy with authority, who was supposed to guide a child to adulthood. Landman *et al.* showed that FP was teacher-centred with the child as a passive learner who was supposed to submit to the authority of the teacher. Furthermore, according to Ashley (1989:23), even textbooks symbolically implied that legitimate authority was not to be questioned. Cohen (1988) reported in Prawat (1992) reiterated that view by stating that teachers were traditionally seen as ‘tellers of truth who inculcated knowledge in students, while students played a passive role by reading, listening and performing prescribed exercises. These 'tellers of truth' were unfortunately often Europeans or Blacks that the education system had assimilated into the European culture. 'These were the teachers whose qualities and truths were to be reproduced in a child. Thus the CNE and FP, intentionally or not, had the potential to wipe out the culture of Blacks from an educated Black. Transformation in education was necessitated by the unfairness of the CNE, FP and the separate education departments for each race such as Bantu Education.

Dewey (1938) reported in Howe (1992) observed that after years of schooling in which children are continually required to master and regurgitate information presented by their teachers, they will develop the habit of expecting (and demanding) that they play this passive role as learners (some kind of laissez-faire learning). He continued that, consequently, although they do not start that way, in time many would come to approximate the positivist-behaviourist model. Having learnt religious, cultural and school knowledge by rote, some South Africans can mistakenly adopt transformation as a doctrine that one has to be moulded into - indeed there are indications of doctrinaire approaches to transformation in education, especially since transformation has been strongly linked with political correctness. Criticism against transformation can easily be labelled unpatriotic by the current leadership.

Hence emotional exchanges were frequent between those for and against OBE in many workshops. It can be concluded that SADTU emotions were directed against the CNE as a tool of apartheid that designated an inferior curriculum for Blacks. These were emotions that were more likely anti-past rather than pro-future, and avoided critical analyses of transformation and OBE. The majority of SADTU members wanted transformation, as long as that transformation removed the past.

3.2 Some of the current curricular problems in education

From the above it is not surprising that many people blame the CNE, FP and Bantu Education for all curricular problems in education. Indeed there are many critiques about the past South African education system. For some reason, other things like cultural differences are not mentioned prominently as possible sources of curricular problems. However, this section tries to outline a few of the problems from the author's experiences and research that the author believes require consideration in planning for transformation in science education.

The legacy of past philosophies such as the CNE and past approaches such as FP is that today, as Prawat (1992) observed, a curriculum still has a fixed agenda, a daily course to be run and consists of pre-set means (i.e., certain material to cover) and predetermined ends (i.e., a discrete set of skills or competencies). Most of these course units have to be memorised and reproduced in a form that examiners favour. Thus, approaches in education are still empiricist and positivist. The Australian Science Teacher's Association [ASTA] (1995:A1.9) said that empiricists and/or positivists view knowledge as already made, 'out there' in the world, only to be accessed and verified by the learner. Hence knowledge is acquired by ‘looking’ out there such as in textbooks and laboratories, verified by special people called scientists that are out of touch of the ordinary learner.

The Department of Education expects teachers to complete syllabi that are too long. For example, during 1983-1994 in the former Transkei, the author could not complete the Standard 10 Physical Science and Biology syllabi comfortably. Similarly, MacDonald & Rogan (1988: 234) concluded that the science syllabi in Ciskei for Standard 6, 7 & 8(i.e. junior secondary levels - 8th to 10th year of schooling) were very long and difficult for the pupils. These long syllabi are not delivered with individual attention to learners because of overcrowding and lack of resources. Appendix I shows that overcrowding reached 80 learners per class in the Eastern Cape Province. Besides, some content appears to be irrelevant and well above the learner's comprehension. For example, the electron configuration in Standard 8 Physical Science syllabus is of no immediate use and appears to be too abstract to the learners. A long and difficult syllabus is likely to encourage rote learning.

Some of the FDE (Science Education) candidates claimed that they were forced to teach subjects for which they were not trained and qualified to teach. For example, the author found Bachelor of Commerce graduates teaching science. Similar requests were made to the author at Lamplough High School (1983-1994) where he ended up teaching mathematics, geography and agricultural science apart from biology and physical science. To many school administrators, a science teacher can try teaching any science-related subjects. This misallocation of subjects to teachers has been exacerbated by the fact that the Department of Education has suspended recruitment of new teachers and demanded a specific teacher to pupil ratios - these ratios do not take consideration of specialised tuition. All these problems can work against transformation in the curriculum towards OBE.

3.3 Some curriculum principles that transformation appears to have followed

Curricular developments in South Africa seem to have borrowed many of the principles of popular curriculum specialists such as Tunmer (1981) and Moore (1982). Tunmer (1981:30) believed that earlier definitions during the 17th Century surrounded knowledge for leadership and elitism, but that political changes from feudal systems to mass democracy and recognition of Human Rights, shifted the curriculum to include all social classes during the 18th century, until the 19th century when the child 's interests became central to the curriculum. It appears from Tunmer's account as though up to 1980 a curriculum was expected to be intended, guided, controlled or planned. This view is implied in the definitions listed in Tunmer such as that of Bobbit (1918), Caswell & Campbell (1935), Krug (1957), Taba (1962), Hass (1980) and others, which showed guidance by the school and teacher-centred approaches. Tunmer's (1981:30) definition, "formally planned for an individual pupil" showed a shift towards the individual learner in terms of activities and experiences rather than knowledge to be acquired or facts to be stored (Tunmer 1981:31).

According to Moore (1982), the procedures of developing a curriculum include a consideration of the worthiness of what is taught in relation to personal, moral, religious and political beliefs, the value of knowledge and how that knowledge is passed on. Moore (1982:53) believed that the educational curriculum was primarily a matter of knowledge, knowing that and knowing how, together with some beliefs and attitudes, all of which it was thought desirable that children should be introduced to. The question of 'what knowledge' led to that of 'what grounds are there for holding that the traditional curriculum should be as it is' (Moore, 1982:54). Moore was in effect arguing that knowledge must be relevant, useful or 'utilitarian' and that beyond relevance, it is required that there should be a clear understanding of how that relevance came about. But according to Barrow & Woods (1982:21), that 'utilitarian principle' should not necessarily always lead to material gain but also to the pursuit of factors extrinsic to that activity.

According to Lawton (1983), relevance is relative to social needs. Lawton (1983:37) said that there are ideas that different social strata (and perhaps different academic levels) have only limited access to knowledge (or limited ways of perceiving reality) - the views of each class are incomplete and conservative since each class has a vested interest in its own progress. Hence knowledge is defined variously by each social stratum. This is similar to the way teachers impose their own versions of knowledge upon the students, without recognising the knowledge or experiences of the students. Learners may reject knowledge because it may not be relevant or making sense to them.

Moore (1982:57) referred to a subject as 'apprehending a form of reality', which, it seems, are traditionally subjects like chemistry, biology and physics. He further said that knowledge forms or disciplines are not mere collections of information but rather 'complex ways of understanding experience which man has achieved'. According to Moore, a form of knowledge is a distinct way in which our experience becomes structured around the use of accepted symbols and symbolic cultural and social expressions such as language. These expressions are means of acquiring, dissipating and validating culture or knowledge.

These curriculum considerations were perhaps well summed up by Luthuli (1985) who believed that people must be involved in the construction of a curriculum, which shall reflect their philosophy of life. Luthuli continued thus, Black education should not mimic the education of Whites, but should consider important skills. That collaboration was further supported by Levy (1993:93) who believed that it was crucial that innovation and curriculum development in the country should inform national curriculum development process and science education policy formulation in order to prevent a replay of the previous education dispensation where curricula were determined by a select group of faceless experts.

3.4 The transformation to OBE

The ANC government embarked upon transforming the curriculum immediately after coming to power apparently following the principles outlined in Section 3.3 above. This was initially done through meetings between subject specialists. New syllabi appeared in all subjects during 1996. The history syllabus was, for example, changed to reflect upon Black heroes positively as well. However, behind the scenes were also plans to change even those new syllabi and replace them with the OBE curriculum. These changes seemed to be too quick for many teachers, including the author who was then teaching.

Ihron Rensburg of the Department of Education, Pretoria said that the urgency for curriculum transformation was beyond dispute (Sunday Times, 8th March '98: 23). Many South Africans would agree, but it appears from their toi-toi that they would probably place priorities in education differently.

Although it appears that priorities of the majority were more material and political than epistemological, transformation in education led to Curriculum 2005, which is OBE.

Curriculum 2005 was unveiled on the 24th March 1997 at Cape Town by Minister Bengu (Daily Dispatch, 25th March 1997). According to Ihron Rensburg, the Deputy Director General of the Department of Education, Pretoria, the phasing-in of OBE was supposed to follow five key preliminary stages (Sunday Times, 8th March 1998), namely:

- Collaborative development of learning programmes and of learner- and teacher-support material involving the department and its provincial counterparts;
- Field testing of all learning programmes and support material in a carefully selected sample of schools;
- Orientation programmes to provide teachers with initial support in introducing the new curriculum;
- Substantive, in-service training for teachers in the period leading up to 2005; and
- Appropriate adjustment of learning programmes of support material in response to the results of the field test.

In line with recommendations of educationists like Luthuli (1985), these phases indicate a participative process of curriculum development that is far from the top-down authoritarian approach of the CNE. OBE is supposed to be a mass-based wholly inclusive approach to curriculum development that involve all stake-holders such as recognised professional teacher associations, trade unions and tertiary institutions (Minister Bengu, 6th July '97 Sunday Times). The minister also said that the Department of Education was trying to set up mechanisms whereby the capacities of the education practitioners in the provinces engage in continuing curriculum development and that teachers will no longer be passive recipients of a curriculum that is built within the walls of a distant Department of Education. The important principle of consultation in curriculum development was at last recognised in South Africa.

Other important positive changes in the curriculum that closely relate to science education include the premise that education is a right for everybody and that learning is independent of age and that OBE could recognise cultural or traditional knowledge and methods. The understanding of the relationship between science and culture is mentioned in Specific Outcome 6 for the Natural Sciences. These skills may include traditional healing and knowledge of traditional herbs. Some cultural approaches may help in bridging the gap between science and traditional conceptual frameworks.

3.5 Problems that threaten the success of transformation to OBE

The process of transformation to OBE may be what South Africa requires to enter the global market, particularly in science and technology in which innovations are important. However, from the author's experience in teaching and from the analysis of results from the author's survey on problems and approaches of science teachers, it appears as though further research and preparations are necessary for transformation and OBE to be implemented successfully. Problems that may inhibit transformation and OBE are wide - the articulation of these problems depends on one's experiences.

In the author's opinion, the most important problems are related with

- politicisation of transformation & OBE,
- foreignness of OBE,
- comprehension of the philosophy behind OBE and its methods,
- false expectations from transformation.
- a quantum leap that is required to shift to OBE,
- differences in priorities between various organs of education,
- the relationship between culture and transformation,
- logistical problems such as time constraints and funds,
- lack of science literacy and
- requirements of tertiary institutions.

Prof. Charles Dlamini stated that education was over politicised, especially during the struggle (Sunday Times, 8th March '98). He further said that pupils were told that political liberation was a priority and that the culture of 'liberation-before-education' will take time to change. The hatred of the past, particularly among Blacks, in some cases has made transformation anti-past, rather than pro-future. This implies removing everything that bears any relationship with the past White government before the future is planned. For example, some political leaders in support of doing away with Matric claimed that Matric is tainted with the old political agenda of maintaining the status quo by using the pass grades to limit the entrance of Blacks into tertiary institutions (Daily Dispatch, 2nd March 1998:8).

The author knows SADTU members who as students toi-toied against Bantu education. Thus, through teachers like these, SADTU's perceptions of transformation can be traced to the days of the liberation struggle. SADTU and SASCO are *de facto* arms of the ANC and some senior positions were spared for SADTU members in the Department of Education. The partnership between SADTU and the government carries political obligations to

SADTU among which could be planning and supporting transformation together with the government. Hence, SADTU vigorously supported the transformation to OBE during curriculum meetings that the author attended in 1997 at the Stirling Teacher Centre at East London, and salary adjustments for all teachers have been essentially agreements between government and SADTU.

The SADTU-government partnership implies that critical issues in transformation and on OBE can take place privately, between the government and SADTU. This can isolate other teacher unions from the transformation debate. Thus some criticisms by White unions are often interpreted as selfishness and as resistance against transformation - White unions are accused of being more interested in maintaining their privileged status quo than in transformation. These accusations gain ground when White unions reiterate the sentiments against transformation that are often heard among the government opposition parties. Thus, political motives often override serious epistemological discussions about transformation.

It should be noted that SADTU appeared to vigorously support transformation to OBE in curriculum meetings without following up that support in schools. It seemed like the support for transformation was directed at White teachers in curriculum meetings rather than for SADTU members in Black schools. Thus many members of SADTU in schools claim not to understand OBE nor has SADTU attempted to organise OBE workshops. The absence of support to teachers might be due to lack of proper comprehension of transformation and of OBE. This observation increases the suspicion that SADTU supported transformation for its political value but is yet to understand its epistemological dimension.

SADTU apparently interpreted transformation as a necessary political front through which the Black majority could impose political agendas upon the transformation process in education. Such political agendas included the occupation of formerly White schools and institutions and the demand that institutions should reflect the racial demographics of South Africa. The occupation of buildings of former model C schools and other formerly White institutions were rarely accompanied by critical epistemological curriculum analyses of those occupied institutions. Thus an impression was created that, toi-toing teachers and students were only interested in the material and employment in those institutions.

The masses expected the new government to materially level the ground with formerly White schools and institutions before embarking upon epistemological problems that were caused by the CNE. Dr. Njobe (speech at his fair well function, 1997) was of the opinion that many teachers thought that the government's preoccupation with Curriculum 2005 derailed transformation from the course of the original priorities of the struggle. Dr Njobe's view was supported by findings by the author from a survey, which indicated that teachers were more concerned with lack of apparatus and laboratories rather than lack of knowledge or problems in the curriculum.

Minister Bengu (Sunday Times, July 6, 1997) admitted that the curriculum debate tended to deal with merits of change as a process and ignored the educational merits of the curriculum (OBE). Bengu's sentiments were echoed by Professor Jonathan Jansen who observed that SADTU was yet to understand the imperative to engage the state critically on the curriculum front (The teacher, September 1997). These sentiments seem to imply that debates on transformation in education have dealt with the need for transformation but not a critical analysis of the content and process of transformation. This view again reiterates the point that teachers desired transformation to get out of current approaches but did not critically analyse the process and desired end result of that transformation. There appears to have been a belief that there must be something better out there. So transformation tended to adopt foreign paradigms for which foreign expatriates were hired or local teachers were sent to places like Australia to study for these new paradigms. The only problem with this belief was that it might have made teachers to adopt a passive stand, expecting 'somebody' to come and work out transformation for them. For example, no or few teachers or students ‘toi-toied’ for further INSET programmes that would improve OBE.

The teacher's toi-toi for salary increases has often been successful. The government had to look at salaries, not only because of inflation, but also because government officials often have very attractive salary packages that are far beyond those of teachers. For example, a Regional Director's salary may more than double a salary of a high school teacher. However, the government claims that the largest proportion of the education budget was spent on salaries of educationists, although the government is not clear about the proportion that goes to teachers. Therefore there were attempts to retrench teachers or relocate others to school that are more needy. Looking at Appendix II, the government may be right on relocating teachers since an average learner-educator ration works out at 35, but wrong on retrenching. Few teachers would accept to be relocated to rural schools where there often fewer facilities and no accommodation - in fact many teachers in rural schools would wish to relocate to urban centres. Thus many experienced teachers opted for "packages' and left for private schools or sought employment abroad.

Since much of the budget is spent on salaries, there are no funds for curricular transformation. There is for example a shortage of OBE materials and teachers say they need them. Ihron Rensburg (Sunday Times, 8th March, 1998) stated that provincial departments of education experienced extraordinary budgetary troubles during 1997/98 financial year. In provinces like the Eastern Cape, such problems are said to be caused by ghost employees and financial mismanagement that are claimed to originate from the former homelands. Teachers such as Moreka Monyokolo are concerned by the belief that funding shortages, training backlogs, staff vacancies and a time crunch are serious difficulties that face OBE implementation (The Teacher, June 1997).

Minister Bengu believed that no academic analysis thus far had exposed lack of content, skewed values and attitudes, or an absence of skills training in OBE (Sunday Times, 6th July 1997). Unfortunately the good in OBE is yet to be understood. For example, in CASME workshops during 1997, and FDE courses in the Eastern Cape Province, teachers had problems in distinguishing between objectives and outcomes - they also still expect some form of recommended materials or textbooks. OBE pilot classes that the author visited grouped learners but instructed them to be silent - the benefit of group work, that of facilitating group discussions, was not recognised and was not achieved in these cases. According to Martin Prew (Education programme Manager, Link Community Development) teachers seriously need in-service training (Focus, Vol. 2, Number 4, April 1997). It therefore appears that the five key preliminary steps outlined by Ihron Rensburg (Sunday Times, 8th March 1998) have not been properly followed.

Many workshops have been cancelled because 'materials' or 'experts' had not arrived from Pretoria. Furthermore, the approach by which the experts instruct teachers about OBE is still largely modernist in that there are time constraints and a timetable for the workshop, prescribed materials and recommended methods. Few questions from teachers are accommodated in OBE workshops because of lack of time, materials or the absence of experts that would provide answers, and often the 'expert' has to catch a flight in early afternoon to somewhere, often to Pretoria or Cape Town.

The ‘expert’ is still the one with knowledge and, instead of transformation proceeding from society; transformation to OBE has apparently proceeded from the political leadership, experts and 'international trends' down to the South African public. A relatively high profile is given to ‘expert's’ ideas instead of teachers' views and to international trends instead of South African trends. It is said that OBE will help South Africa to adopt international standards and to be competitive on the world stage (although OBE is doing away with competition between learners). Therefore the curriculum is still subject to some parameters that are foreign to the teacher who has to achieve 'international' standards. The internationalisation of the curriculum and the fact that many teachers did not participate in its finer details of OBE makes OBE foreign and distant from solving specific local problems many of which may be unique to South Africa. The contradiction is that teachers are supposed to achieve outcomes locally that are of international standards. In that regard, teachers are correct to demand apparatus and laboratories that go with 'international' standards.

Hence, some of the transformation processes have been structured around doctrinaire approaches of 'must' (that originated from culture, religion and the CNE). Transformation is taught to people. For example, every education programme ‘must’ feature a female and a male, a Black, a White and sometimes a Coloured and Indian and all languages ‘must’ be used in all mass media and each of these has to show appreciation for or has to act the other culture. However, must a White learn Xhosa dance to prove that he is a transformed South African? That would be a doctrinaire approach and contradictory to true transformation.

This approach by which every person 'must' conform to transformation as desired by the government, might limit freedom that will be accorded to an individual school, for example, to play around with the curriculum in various contexts is still to be clearly debated. For example, conflicts regarding languages of instruction continue even after the CNE. Prof. Charles Dlamini argued that Black learners perform poorly at Matric because they study in a second language (Sunday Times, 8th March 1998). He suggested a consideration of mother-tongue instruction, for which coincidentally Afrikaners have long campaigned but were accused of perpetuating racism or apartheid.

It is possibly due to the doctrinaire approaches that transformation has not allowed for cultural adjustments. Some of the new curricular recommendations clash with many cultures. For example, although corporal punishment is abolished at school, it remains in use in many cultures. In many South African cultures, girls learn cooking and cleaning - this is extended into school and finally relates to the respect accorded to women. Yet, gender equality demands similar duties for boys and girls at school. Furthermore, discrimination is a dirty word although the freedom of choice, particularly the choice of association when for example the Xhosa king invites only his subjects, inevitably involves discrimination.

It may not be easy to achieve centrally determined outcomes in the wide variety of cultures and environments. Although the wide variety of cultures and environments seems to be catered for by general statements in Critical Outcomes, these can be miss-understood, interpreted differently or be abused. Specific Outcomes seem to focus on the unique skills in each Learning Area but at the same time can easily compromise variety or cultural values and norms. For example, Specific Outcome 3 for the Natural Sciences requires the application of science knowledge to solve problems. However, until science explains and embraces traditional methods, different cultures may find a dichotomy between what is believed to be science and their traditions such as traditional medicine and problems in their traditions such as illnesses that modern medicine has failed to understand and heal. Yet if each group moves to design learning programmes geared towards its culture (including language) or problems in the immediate vicinity, and therefore interpret outcomes in terms unique to its environment, culture and needs, it will be some sort of apartheid. For instance, outcomes relevant and achieved in an elite suburb school are likely to differ from those in a remote rural village with little income. The village people may at a later date complain that their children were made to learn outcomes that do not help them to get jobs in towns because the environment was not conducive for such outcomes.

Due to apartheid, material distribution is related to race. Whites have more than Blacks and are often found in urban centres. Within Blacks are an assortment of different tribes and cultures. Such variety would require different curricula for each group of people. Luthuli (1985:82) however pointed out that many people (Black and White alike) believed that when one talks of equal education that meant that one day, education for everyone in the country or even in the whole world will be the same. Luthuli pointed out that that was indeed a futile dream. To Luthuli, equal education meant the provision of equal opportunities for self-actualisation and self-realisation. Luthuli continued that this is not made possible merely by the provision of a myriad of gadgetry.

Stephen Mulholland may have a point in saying that sociologists, rather than educationists, seem to drive OBE (Sunday Times Business Times, 8th June 1997). Thus, the merits of transformation have often focused on demanding the material and social ideals of the 'advantaged' instead of the epistemology of OBE. For example, the formerly disadvantaged communities wrongly look at former model C schools as models of the ideal curriculum, expected of OBE. However, that model C communities and teachers did not actively participate in formulating OBE, might be an indication that their curriculum is different from OBE.

There could be OBE ideals that are found in the model C curricula, although OBE is not expected to meet model C curricula. However, voices are heard from formerly disadvantaged schools that OBE's success requires well-equipped laboratories and 'standards' that are characteristic of model C curricula. Such voices seem to echo actions of the political and SADTU leadership, and of Black principals and education managers, who, despite being vocal about transformation to OBE, have taken their children to former model C or private schools. The demise of OBE may partly emanate from Black schools trying to emulate the curriculum in former model C schools, from the leadership’s children leaving the most needy Black schools and from the hypocrisy of the leadership that do what they do not preach.

It is a paradox (or hypocrisy) that that the leadership take their children to formerly White schools and institutions whose curricula have remote similarities to the transformation that is preached to the masses. Black academics also show pride in gaining positions in formerly White universities, instead of developing or transforming Black universities. For example, former model C schools have prefects who have been long replaced by SRCs (seemingly with disciplinary problems) in the transforming schools. Furthermore, former model C schools have laboratories and apparatus while Black schools are requested to improvise in the name of new approaches. The case where Prof. Mokgoba wanted to be the Vice-chancellor of Wits University even drew ANC support. By their actions, the Black leadership do not show trust in Black schools and institutions, and therefore in the transformation.

Many were disappointed when transformation did not put their children into former model C schools or White universities just like transformation seems to have opened doors for the children of the leadership. Transformation apparently only succeeded in removing colour discriminations in formerly White schools and institutions, and only for those who can afford the fees. The disappointments were demonstrated by toi-toi in most of the White tertiary institutions such as Wits, Rhodes and Pretoria Techinikon.

Lack of a smooth transformation to OBE may cause confusion between OBE and the old methods of administration and of classroom practice. The shift to OBE requires a quantum leap - a transformation of all or nothing (i.e., one is required to practice OBE or nothing). This is because OBE has been introduced as a whole package rather than in small doses that are intelligible to teachers. Gradual transformation is apparently expected after achieving basic OBE skills. Even then, few teachers have received adequate basic OBE skills and many of those that have been trained claim not to understand OBE yet. There is a danger of some teachers failing to achieve the minimum quantum energy. Such teachers may find themselves in some undefined orbitals, using methods of teaching that belong to neither OBE nor the old methods. For example, the transformation the CNE and OBE, between learner-centred and group work approaches, between a national and a provincial curriculum and between norm-referenced and individual evaluation may not easily be defined.

This is linked with another problem with OBE implementation, that the transformation process involves reference to paradigm shifts that are not clearly defined in South Africa. It is difficult to know what paradigms are operating currently in South Africa such that the term 'paradigm shift' is rather loosely used to the extent of becoming rhetoric. Many of the paradigms, and curricula such as the CNE, were never practised verbatim but remained in government gazettes, perhaps in a similar manner that ‘real’ OBE might remain in government and academic offices. Education has experienced significant instability under every regime such that none of these paradigms or curricula have been absolute and a bit of each paradigm could have been experienced variously in different institutions, particularly when one considers the multicultural nature of education. Conditions in South African classrooms and many cultures rarely provide opportunities to practice such things as constructivism, or according to Howe (1992), such theories are insensitive to the intricacies and limitations of actual practice. For example, there is overcrowding, the language problem and much of the knowledge of the learners appears irrelevant to the topics in the syllabus to effect constructivism or social constructivism. All these varieties of conditions imply a cocktail of paradigms, many of which are yet to be defined. To extend what Ursula van Harmelen's (Rhodes University lectures) view that a paradigm may look different through different lenses, a paradigm could possibly not be visible, be acknowledgeable or identifiable in some cultures or contexts. It may be unrealistic to talk of transforming between ideologies that have never been effectively practised.

Neither are the new paradigms well understood. For example, of post-modernism in which OBE is expected to operate, Doll (1989: 243) was of the opinion that it was not easy to define and reported Toulmin (1982: 254) saying that the post-modern world was so recent that it had not yet discovered how to define itself. Demarcating paradigms in time and space may be unrealistic because the human brain or human actions may not easily be categorised or programmed into paradigms. Human beings do not act according to paradigms and paradigms only attempt to describe human behaviour. Many experiences such as toi-toi, Ubuntu and Masakane probably have a unique paradigm of their own that is not found in any institution of learning, and no education mechanism has been planned to transform toi-toing teachers and students into critical thinkers and performers of experiments in science. It may therefore be dangerous to plan the transformation to OBE with the assumption that educationists can understand and draw the line between paradigms that operate in South Africa.

Similarly, it is perhaps partly because of the difficulty to define paradigms such as toi-toi that operate in South African schools that the majority of Matric products find problems to meet the entrance requirements of most recognised tertiary institutions, many of which try to operate in defined paradigms. Many institutions of learning are not and cannot be based upon the requirements and values of the majority or on undefined paradigms and experiences like toi-toi because institutions are inherently selective, need money to survive and serve specified job markets. That student toi-toi, Ubuntu and Masakane can not be accommodated in most tertiary institutions could have disappointed many undergraduates. Undergraduates seem to expect Ubuntu and Masakane when they toi-toi for lower fees – to them that expectation may be based upon their concept of transformation.

Institutions have to show stability and high standards, and tuition fees must be paid. Academic requirements involve examinations and institutional cultures and norms, such as language, all of which are not socially constructed by the majority. Selectivity and the high cost of education confer academic and social status to the graduates. It is therefore a myth to seek transformation that would provide tertiary education to everybody because graduates will then have no value and status. If graduates have no value and status, tertiary institutions will also have no value and status. Furthermore, if the majority were to become university graduates, there would arise another criterion that would still select from amongst them to fit into the limited job opportunities. Thus, institutions would not survive if they were transformed into open systems - institutions may have to operate as closed systems in order to survive and can not transform to Doll's open systems and OBE easily.

Transformation has also been hijacked by some scrupulous businesses to sell their products and to impose values of some classes of people. Businesses project science and technology in a positivist manner. Products that are said to be the ‘ultimate’ solutions that have been hitherto denied the masses are literary hammered into television viewer's hours on end. For example there is the ‘Fitness Flyer’ machine advertised on the TV that is reportedly the ultimate result of protracted research by 'scientists' who seem to be carefully selected to represent males, females and different cultures and races and these are shown in a super-technical laboratory. This advertisement also shows the ‘correct’ figure that results from the use of this machine, and the ‘correct’ way of exercising.

Assuming that Black unions have the political upper hand in the course of transformation in education, ‘toi-toing’ teachers and students misused a golden chance of using their political power to criticise and transform epistemological aspects of education when the readiness for transformation among all South Africans was high (i.e., immediately after the first democratic elections). The system is slowly closing again upon the critical debates as the public is trying to make sense of transformation - few aspects of transformation are seemingly open to further debates.

4. TRANSFORMATION IN SCIENCE EDUCATION

4.1 Science education today

From Chapter 3, it is fair to claim that the CNE, FP and Bantu Education, and the current efforts to transform those methods influence Science education. Issues that specifically relate to science are discussed in this chapter. Some of the issues will draw upon Chapter 3 above. Furthermore, some of the evidence on problems and approaches that was gathered by the author in small-scale survey in some schools in the Eastern Cape Province is used. Data is also obtained from the author's past experiences in schools in the Eastern Cape and as a student at tertiary institutions.

Gilbert & Watts (1983:62) and Sutton (1996:1) based the problems in science upon the philosophy of ‘school science’, that seems, to have misrepresented the nature of science for decades. According to these authors, school experiences were responsible for the persistence of views (variously characterised as ‘empirical-inductivism’, ‘inductive realist’, ‘naive empiricist’, ‘Baconian’, ‘positivist’, or ‘scientistic’) which helped to maintain an inadequate public understanding of the scientific enterprise and a degree of alienation from it. The values ingrained in empiricism, for example, assume an unprejudiced or ‘blank’ mind and perfect ‘objective’ sense organs such that absolutely true and similar observations are made all over the world. These were supported by Ayayee & McCarthy (1996:55) who reported that positivism asserts science as a body of facts derived from unbiased observation of the environment. Therefore much importance is placed on the verification of theories.

According to Sutton (1996:2), there are assumptions that there exists a simple logical path from evidence to theory, especially when prescribed methods are used. That each individual could follow a different thinking path and could demonstrate his understanding in a way different from that required by ‘scientists’ are not acknowledged in science. Interesting though is the fact that the arts, such as music, fine art, design and writing, recognise and highly applaud individual expressions.

An overview of the historical landmarks shows that science education has lost the ways of people who contributed significantly to science. The following passage is an extract from a paper by Prof. Fred L. Wilson of Rochester Institute of Technology (

> "After all, the greatest scientists of all time, Isaac Newton, Antoine Lavoisier, Dmitri Mendeleev, and others, often did not get it quite right.

> … a division is artificial, and is based on intent of the individual doing the work... True, science is full of useful inventions. In addition, its theories have often been made by men whose imagination was directed by the uses to which their age looked. Isaac Newton turned naturally to astronomy because it was the subject of his day, and it was so because finding one's way at sea had long been a practical preoccupation of the society into which he was born. It should be added, mischievously, that astronomy also had some standing because it was used very practically to cast horoscopes. Kepler used it for this purpose. In a setting which is more familiar, the English physicist and chemist Michael Faraday (1791-1867) worked all his life to link electricity with magnetism because this was the glittering problem of his day; and it was so because his society, like ours, was on the lookout for new sources of power. Consider a more modest example today: the new mathematical methods of automatic control, a subject sometimes called cybernetics, have been developed now because this is a time when communication and control have in effect become forms of power. These inventions have been directed by social needs, and they are useful inventions; yet it was not their usefulness, which dominated and set light to the minds of those who made them. Neither Newton nor Faraday, nor the American mathematician Norbert Wiener spent their time in a scramble for patents…"

Science education in schools comprises of content and methods of the historic scientists such as Newton, regardless of relevance, some of which have become obsolete in face of new discoveries. The current science curricula are static and written as finished products, and limit one's school career to a defined set of facts. Aikenhead's (1994:5) view that traditional science teaching methods tend to be characterised by convergent thinking and lecture demonstrations fits the South African science education scenario. There is for example a prescribed textbook that purportedly contains all the science or biology facts that one needs to pass Matric. Students are required to prove rules and laws that were made in the past. The school science course can easily be titled 'History of Science'. For some unknown reason, contemporary scientists or science discoveries do not appear in the South African science syllabi. Neither does science relate to South African indigenous cultural or traditional knowledge, methods or frameworks to enable effective constructivism. Urevbu (1987:11) blamed this to the desire of passing examinations which has led to the creation of syllabuses based on materials and criteria that are examinable and not necessarily useful to society.

Aikenhead & Ryan 1989 (Aikenhead 1994:7) observed that traditional science education succeeded at mystifying the general public by sustaining such myths as objectivity and certain truth. Furthermore, Mphahlele & Kahn (1993:161) observed that ideology of science professes that meaning of science is fixed, given and free of cultural values. Mphahlele & Kahn continued that this view of science reduces everything to fixity, universalism and facticity such that it silences those who are not initiated into the rules of science or the "right universal scientific principles". Objectivity can not be located in the frameworks, environment, tradition or culture of the learners, particularly in 'third world' communities. Hence Sutton (1996:2) reported accounts of varied insights of historians, philosophers and sociologists that questioned some of the taken-for-granted routines of school science. These insights included ‘a socially constituted enterprise shaped at many levels by human values, beliefs and commitments’.

Science lessons always start with these ‘right universal principles’. The implication of this approach is that there are already 'known' and acceptable explanations by the ‘scientists’. Many times learners are told that something happens because “according to Ohm’s law…..”. That is probably why, according to Ayayee and McCarthy (1996:64), somebody is expected to convey science to pupils. As a result, science teachers have become good storytellers in class, only that they claim their story to be the truth behind phenomena. The truth is not practised because no body knows how to or because there are no apparatus, and is rarely directly relevant to learner’s needs or interests. Thus learners have to believe and memorise science and do not get challenged. The learners’ belief in teacher’s stories without question probably arises from the effects of FP and many cultures that consider learners or children as followers that are led by the teacher or adults through the fairly tales of science. Nonetheless, learners are able to get excellent grades in science.

A similar approach, of proving the truth, is used even when an experiment is done. Sutton (1996:2) put this view with sanctity by saying that ‘scientific truth pre-exists its discovery’. Experiments at schools are about proving laws, such as Ohm’s Law or whether light is essential for photosynthesis. Teachers start experiments with statements such as “Today we shall prove Ohm’s Law …” or “This is how we prove that light is essential for photosynthesis”. As a result the learners’ observations are directed and convergent to the selected phenomena in a laboratory, and start from an established truth.

Gough (1993:13) referred to laboratories as being fictional because they are fashioned by a human agent and are likely to impede learners of the meaning and significance of science. In the South African schools, objectivity and universal truths also apply to the use of apparatus and the laboratory. Gough (1993:20) observed that school laboratories neither resemble the sites in which most scientists work nor are they used for the kind of experimentation and data generation that characterises much professional science. Hence, according to Denny (1986:334-335), pupils consider science practical work as having relevance to the lesson and to the laboratory and none beyond. Laboratories can be described as places where students follow recipes, perform routine procedures, rehearse technical skills, demonstrate the reliability of selected (‘well-accepted’) scientific ‘laws’ and falsify their data when they get inconclusive or unexpected results. Thus, to many learners, science is a package that is found in apparatus and laboratories but not elsewhere, such as in their homes.

Further to Gough’s views above, there are suggestions that practical work in science education is ill-defined (Gott & Duggan, 1996:791). Gott & Duggan suggested that the situation with practical work has been one of confusion, which may leave teachers without a sound rationale as to precisely why they are doing practical work. For example, laboratory tasks fall short of open-ended investigations and student autonomy that should be characteristic of laboratory tasks (Olsen, Hewson and Lyons (1996). Alberts, Beuzekom & de Roo (1976) as well as den Berg & Giddings (manuscript, year of publication for both is not clear) said that reasons for giving practical work can vary enormously, from being an aid to optimising the learning process of the theoretical content, to teaching pupils practical skills. In the opinion of den Berg & Giddings (? :5) the main weaknesses of laboratory-based science teaching included: lack of distinction between priorities and objectives, choice of experiments, mismatch between laboratory goals and written laboratory instructions, or teaching strategies and assessment practices. Few teachers in South African schools may be able to differentiate between these issues and a practical has always been taken as described in the textbook. Nonetheless the belief in practical work is so deep that experiments are often also memorised to pass examinations. Subject advisers, teachers and students have always based poor performance in science upon lack of apparatus and lack of laboratories. Society has been made to believe that science knowledge is acquired through particular experiments. For example, Matric science comprises of a set of experiments that ‘must’ be done – nothing less or more.

Furthermore, Gott & Duggan (1996:791) said that an understanding of scientific evidence would emerge, as a result of doing practical work is questionable. Other sources showed evidence of teachers' fears that something unexpected may be discovered in an open-ended investigation (Denny, 1986:334-335). In a survey of classroom approaches, the author found that learners did not have a chance to question or to critically analyse the knowledge that was given to them. For example, in a demonstration, it was predicted that a bulb would give out light. When the bulb did not light the first time of connecting the circuit, the two students tried again and again until the bulb gave out light. The failure to give out light was not investigated because the truth was that a bulb lights when connected according to the teacher’s instructions. If learners observed anything else other than looking at the bulb to see whether it will give out light, they kept that to themselves. For should learners point out some other phenomena during the experiment, the teacher would have most likely advised them that their observation would be dealt with later or at a higher grade – teachers often demand that the learners’ observations must be focused.

It is such confusion that surrounds practical work which creates a perception that there have to be test tubes and some wires in a laboratory for any activity to qualify as being scientific -- basically a laboratory must have something that looks foreign or uncommon inline with the foreign nature of science. But foreign objects attract unintended learner attention. In the author's experience in Physical Science lessons learners were more amused by the equipment than the concept that was being illustrated. For example, learners could occasionally concentrate upon the shape and motion of the Van der Graaf generator, but not the electrostatics properties it was designed to demonstrate. No wonder that the author's survey also indicated that teachers and students believed that electrostatics was among the most difficult topics.

Since practical knowledge can be memorised for the examinations then the teacher can as well not bother about carrying out the practicals and resorts to the textbooks, chalk-and-talk to teach science. Dillon, O’Brien and Moje (1994:346) reported that Finley (1991) and Chiapeta, Sethna & Filman (1991) found from research in science education that textbook-based instruction dominates most science classrooms. But textbooks and the teacher’s talk are not easy to comprehend by learners because they are written in English that is not a first language to the majority of learners and have illustrations that are foreign – learners may not be able to follow instructions in practicals either. Hence Dillon *et al.* further stated that that method of teaching highlighted the difficulties' students encountered in learning and studying from science texts and the impact reading has on conceptual understanding. Furthermore, Dilon *et al*. said that there was evidence that text-based instruction is inadequate in meeting the goals of science education. This evidence reaffirmed Gough's (1993:13) belief that textbooks were so fictional that they were likely to impede learner’s understanding of the meaning and significance of science. Readability and comprehension of science textbooks was also a matter of concern pointed out by Kuiper when he compared different textbooks (lectures, 1997).

Solomon's (1994: 5) view that the classic view of language is that it is a code of meaning that we use in fairly uniform ways to communicate what we have already thought and observed, and to generate an understanding of it to others. In an interview, the author found that learners expressed themselves better and discussed more freely when they used their vernacular. Many Black children are not proficient in English language and so do not easily understand science and are unable to communicate their ideas and questions or are unable to participate in national and global scientific debates. Learners found problems in expressing themselves in English in an interview by the author. This finding supported Rutherford's (1993:261) view that scientific language was a major hurdle for novice scientists. Rutherford pointed out that, in South Africa, with many vernaculars, it was unlikely that the medium of instruction will be the mother tongue of the majority of the population in the foreseeable future. Furthermore, Rutherford said that although only about 5% of the population was English first language speaking, the medium of instruction seems likely to be English for at least 90% of the children. The problems of scientific language are therefore exacerbated by the problems of second language learning.

Gough (1993:14-18) and Sutton (1996:11) also believe that the perception people have of science has a lot to do with language usage. They believe that a change in the generality of statements as time goes on, tends towards presenting early writings of scientists as facts. Furthermore, accounts of something done by scientists are later replaced by statements which aspire to a universal validity, and are no longer about specific times, places or people. Sutton suggested that it is the firmness with which we use 'factual' language in school that leaves learners with the impression that the scientists go out to 'discover' facts in the natural world, by doing things and 'seeing what happens', rather than by any process of imaginative effort and painstaking construction. Human endeavours and controversies are hidden behind facts that are presented as science laws. Laws seem to have been there all the time, and the role of the scientist was just to go out and find them. Thus learning science is no longer a natural process that is based upon impromptu natural phenomena in the environment. Rather, a learner reads about it and follows the instructions set by a scientist.

Sutton further said that textbooks offer the product of science not as an interpretation at all, but as a ‘simple’ account of how the world is, just as if it had been read off directly from nature. That the Department of Education, as an authority, goes on to recommend textbooks such as that by Brink & Jones goes a long way into misleading students and teachers into believing the textbook rather than their experiences. The author has experienced occasions when students and teachers did not accept the author's corrections of a textbook. Similarly the author found some Matric examiners who believed in the 'facts' in the textbook rather than the teacher's account of observations of experiments in their classrooms.

Teaching remedial English, especially as used in science would be recommended if there was enough time. The schooling period is limited to the extent that science can not include practical approaches. All learners, regardless of their difficulties (like language), pace and style of learning, must learn those science facts in a prescribed period. Apart from compromising proper science teaching, the limitation in time of schooling also leads to cramming too much knowledge into a short time. This implies that a selection of science knowledge both in depth and breadth have to be made. The learner is also told that he can study that far or that deep at a particular level on a given topic of science. For example a Physical Science student at Matric is told clearly that he should not bother about Oxidation Numbers at Matric level regardless of his interest in that topic - he will find that topic if he pursues chemistry at University. It is during that selection process that some vital knowledge can be eliminated and irrelevant knowledge included. The Matric Biology syllabus, for example, is too long that experiments are sacrificed to complete the syllabus, and leaving out initial knowledge, such as AIDS. This in turn leads to chalk-talk teaching, memorising and irrelevance.

The different science subjects are also not properly co-ordinated. For example, the structure of atoms and organic compounds are studied at the beginning of Standard 10 in Biology. In Physical Science, atomic structures are dealt with in Standard 8 and then Standard 9, while Organic chemistry is dealt with during the third quarter in standard 10. It may be confusing to learners that a portion of a particular phenomenon belongs to a different class of science. For example light is not studied in detail when dealing with photosynthesis in Biology because such details are considered to fall under Physics. These demarcations can dampen enthusiasm and can make it difficult for learners to re-integrate knowledge for meaningful application in real life situations. For example a learner has to integrate knowledge about electricity, mechanics and heat to understand how a combustion car engine works.

Most of the scientific approaches and content favour urban settings more than rural settings. It could be because educationists have endeavoured to make knowledge relevant to development. Development has often meant ‘modernity’- a process that brought into being the modern capitalist industrial state, according to Sarup (1993:130). Sarup (1993:131) continued that modernisation referred to the stages of social development that were based upon industrialisation and that modernisation is a diverse unity of socio-economic changes generated by scientific and technological discoveries and innovations, industrial upheavals, population movements, ... and urbanisation, all driven by the expanding capitalist world market. As a result, science curricula are not contexualised to deal directly with problems that are important in under-developed communities, such as food production, AIDS, abortion, housing and water conservation. There has often got to be research to make modern science applicable in most third world communities.

Jenkins (1990:44) reported claims that science was transformed during the 19th century and that the divorce between natural knowledge and the general culture was effected from 1870 to 1900. Therefore science was no longer related to everyday life, but to ‘modernism’ of the industrialised world, by the time it was introduced into the ‘third world’. It is worse with African countries where 'modern' laboratory science or industrialisation has never been part of their daily life. The problems between science and society in the third world are rooted in the isolation of science knowledge and methods from traditional values and norms of society. Science has demonised and invalidated traditional approaches. For example, some time ago, the author’s 16-year-old girl believed that using herbs makes one a witch. Similarly, Mphahlele and Kahn (1993:161) claimed that Chinese, Indian and African scientific discoveries, for example, are seen as peripheral contributions to ‘western science’ and not scientific innovations in themselves and that examples and explanations come from the European culture and are given universal status. Hence, scientists scorn upon traditional methods in Africa.

Among obstacles that hinder science in Africa, Ogunniyi (1996:271) listed lack of indigenous technology development and negative effects of imported technology. Other critical factors in Africa that contribute to poor performance in science, technology and mathematics were identified as being due to teachers, the student, the school environment, the home environment, the society, nature of subject, nature of examinations and government policy Ogunniyi (1996:267). Furthermore, the text of the Dakar Declaration indicated that, efforts towards human power development in the fields of science and technology in Africa invariably came up against large socio-economic obstacles (Ogunniyi 1996:268). In the South African context, apart from problems already listed, the list of obstacles against science include lack of science apparatus, cost of laboratory equipment, lack of qualified science teachers, lack of investments into science research, a shortage of scientists and cost of training science teachers. Lack of funds, by both government and private companies mean lack of what many would see as 'luxuries' such as research and apparatus. Communities can not afford the prescribed equipment for the 'laboratories' neither can the government buy such equipment for all schools in South Africa. Thus, Africa is failing to cope with the pace at which the 'First World' is developing scientifically and technologically. Africa ends up receiving already made knowledge that has to be learnt or memorised.

4.2 Some of the issues related to transformation in science education

The need for change to provide education that prepares everyone for a rapidly changing future was emphasised by Kuiper (1996:7). However this change ought to be preceded by change in society. Change in curricula requires both academic and political direction and leadership. That is why OBE was possible after a change in government. The challenge, however, is how to effect transformation without imposing ideas upon the masses.

Kuiper (1996:7) continued that the discipline of science is no longer seen as mostly theoretical, and that as a positivist, linearly progressing enterprise, science has run its course. Thus science should be deconstructed and reconstructed. According to Ursula Harmelen (lectures at Rhodes University, 1997), this reconstruction requires social constructivism and post-modernism. Understanding science concepts require concrete and shared experiences in a context in which such terms are applied if there is to be an adequately socially constructed meaning.

Constructing knowledge is done by the cognising subject, not passively received from the environment and is an adaptive process that organises one's experiential world - it does not discover an independent, pre-existing world outside the world of the knower (Lerman reported in Matthew 1992:301). This means that concepts must be based upon experience (Urevbu, 1987:6) - that is, education has to relate directly to the each persons' environment in order to enable need for learning 'in-touch' as pronounced by Ursula (lectures:1997).

ASTA (1995:A1.10) reflected upon the constructivist - interpretative paradigm relationship in the statement that knowledge is constructed through social interactions, as individuals test the fitness or usefulness of their ideas or conceptual understandings in interactions with others, and in the contexts in which they apply or use their understandings.

Meighan (1981:229) said that language allows men to respond to and direct the experience and actions of other persons and that an important dimension of the formation 'self '(or the I, according to Ursula) involves language. Humans develop an accumulated collection of other people's perceptions, impressions and beliefs (Meighan, 1981:229). In South Africa the main teaching language, English, is not understood by the majority of students (Rutherford, 1993:261). However, English is convenient for international and inter-tribal communication and for acquiring new relevant knowledge. The recommendation that many languages should be recognised is important because languages improve communication skills of learners and so contribute towards a healthy debate about issues that affect all communities.

Constructivism is based upon the belief that knowledge is a human construction and that further knowledge or learning is built upon previous knowledge. Gunstone (1990) stated that personal constructions have a major impact on science learning through their being the context the learner uses to interpret the idea to be learned and link ideas to be learned with what is already known and believed. In this case it would seem that constructivism agrees with the interpretative paradigm in that the understanding of the individual learners is considered to be central in constructing or acquiring knowledge. For example teachers use concept maps of each individual learner to teach that individual new things. There is therefore a possibility that students from different backgrounds will observe and draw different conclusions from the same phenomena. But such conclusions have to be communicated, for example, when learners write their reports about observations that they have made.

According to Matthews (1992:299) constructivism is one of the major influences in present day science and mathematics education. Constructivism is a popularly recommended method of teaching science in South Africa. Solomon (1994:4) pointed out that Piaget, Driver and Easley were clear on constructivism, and that Piaget wrote that in psychology, as in physics, there are no pure ‘facts’. Phenomena are not presented nakedly to the mind by the phenomena of nature but are the systematic framework of existing judgements into which the observer pigeonholes every new observation.

Although evidence that relates language with construction of knowledge is not conclusive, the use of a mixed-language approach makes sense in pragmatic terms and appeared useful in a learning environment among Swati-speaking pupils (Rollnick and Rutherford, 1996:102). The author has had similar experiences when teaching Xhosa-speaking learners. On occasions the author had to translate, or ask a student that seemed to understand a concept or object to translate it into Xhosa. This seems to help learners to appreciate the implications of a concept. The use of a mother language may improve the learner's ability to construct meaning in classroom activities using knowledge from home or culture.

Concerns of communication skills relate directly with the concept of science literacy. Dillon, O’Brien & Moje (1994:345) found that reading, writing, and oral language were important vehicles to learning science concepts within daily classroom activities. Literacy is basic to the development of important skills in science such as thinking skills because the thinking process uses symbols such as language, pictures and shapes of equipment. In designing for learning activities which embody cognitive conflict strategies, Nussbaum and Novick (1981) (reported in Gilbert and Watts, 1983:85) suggested sequences that teachers may use to effect restructuring of student’s frameworks in order to accommodate new knowledge, that is, in order to learn. These sequences included the teacher encouraging the students to verbally and pictorially describe their ideas, the teacher assisting students to state their ideas clearly and concisely and students to debate the pros and cons of different explanations that have been put forward. In that regard science literacy contributes towards the relevance of learning science and towards understanding the underlying philosophy of science and science education. Similarly, Sutton (1996:11) recommended that we should show pupils that the statements of science were not universal at their inception, and help them to emphasise with the interpretative effort and argument, which the scientists experienced. He also recommended that language should be used as an interpretative system, which makes sense of experience.

The explosion of science knowledge requires literacy skills that help learners to unlock and acquire knowledge and assess the relevance of that knowledge. These skills will change the learning process from transmission to skills of acquisition and interpretation of knowledge. For example they have to know how to use the library, the computer and the INTERNET, and to know how to sift out relevant information, make summaries and do research. Gott and Duggan (1996:793) believed that being scientifically literate requires, amongst other things, that pupils have a sound knowledge base in the major substantive ideas of science and ideas related to the collection, validation, representation and interpretation of evidence. This is a skill that could be among science teachers.

Literacy skills have to be backed up by hands-on experiences that are centred on the learner's understanding of the world upon which further knowledge can be constructed toward useful skills. The hands-on approach is not a new idea and can be traced to earlier education curricula. For example, Ornstein & Levine (1984:76) reported that skills were part of curricula of primitive societies during 7000 - 5000 BC. Many cultures in South Africa informally pass on skills to their offspring through demonstrations. Society is not short of skills to pass on in classrooms, but such skills need to be facilitated in schools. There are skills that lead directly to employment and self-reliance like brick laying and repairing appliances.

Community involvement will enable the community to include knowledge that is relevant to its environment and values. Hence social constructivism is relevant at this time of transforming education toward a world order in which people are in control of their own destiny and environment. Through social constructivism South African communities will be able to critically re-examine and reprioritise their values and norms, and will determine the exact skills that are useful for their community. Crucial values include the use of science and technology to preserve the environment and culture. The involvement of communities is central in the OBE curriculum. This is because the acquisition of knowledge and outcomes or skills will be learner-centred with the community of that learner determining the skills in form of outcomes. Outcomes will relate to the most relevant, needed or wanted skills in every community or environment.

Skills' development is meaningful if it can harness the resources in each region. For example rural communities might want more of farming skills and learning how to manage notorious crop pests and pollution due to fertilisers. Urban communities on the other hand, may be concerned with wastage management. The learner will perform skills or outcomes to show that he can apply these skills for real life solutions. Such skills empower individuals with a potential to develop themselves, employ themselves and to become self reliant in their environment.

Once skills are environmental based, people are likely to be sensitive to their environment. Serious issues such as pollution, fires, *dongas*, over stocking by livestock and a high human population (birth control) can be debated in the classroom. Such debates can lead to lively lessons about ecology, abortion and food production. Problem solving will also compel people to seek solutions, in which case skills such as investigation or research, problem solving and reporting will be developed.

Abstract skills such as critical thinking ought to be encouraged. This is in support of Moore's (1982:57) idea that a curriculum is also justified to the extent to which it produces a rational mind. Activities during learning exercises or during practicals can be designed to encourage critical thinking. Practical work should be planned together with learners so that they can take part fully in the problem formulation and conclusion - the involvement of learners that way can induce critical thinking about their problems and knowledge that is obtained from the experiences.

Practical work will also be set in form of research investigations around problems rather than as a means to prove some set of ‘facts’. The relevant facts or laws will inevitably surface in the course of the investigation. Denny (1996:335) suggested that teachers should encourage divergence, open-endedness and genuine discovery among learners. Open-ended investigation or research will eventually lead to the development of indigenous knowledge and solutions. Knowledge that emanates from locally conducted research can go a long way in preventing rote learning and in facilitating technological development and environmental awareness. Localised research will also reduce the dependence of science education on imported laboratory equipment that is often too expensive for most schools to afford.

The explosion of knowledge also implies studying throughout life (life-long learning). Thus in future, qualifications may be about life skills, such as acquiring, assessing, processing and applying knowledge rather than about an assemblage of facts.

These suggestions require new approaches in the science classroom. These approaches are included in the new OBE curriculum. A new perspective on what science is - a process of knowledge construction that is holistic instead of reductionist - is emerging (Kuiper 1996:7). In science, forms of reality referred to by Moore (1982:57) form Natural Science. This is because phenomena are integrated in nature. For example, the experience of children with water is not in form of physics, chemistry, biology and geography each of which subjects has a section on water. The experience with water cuts across all of these traditional subjects.

The experiences of children will be translated into nine Specific Outcomes in the Natural Science Learning Area. These outcomes are supposed to lead to an increase in scientific literacy, interest in science and technology, encouraging interest in interactions among science, technology and society and helping students to become better at critical thinking, logical reasoning, creative problem solving, and decision making.

A report by the Technical Committee & Support Team of the Natural Sciences Learning Area (March 1997)[hereafter referred to as the 'Report'], clearly gave the rationale for Natural sciences on page 5. It is important to note from the Report that an integrated approach to science and the acceptance of the dynamic nature of science knowledge are both inherent principles to be upheld in Natural Sciences. It is also inferred that learners have to understand their natural world, such that those in rural areas will have a chance to be accredited for knowledge of their immediate environment.

Teachers need to think and reflect critically on their practices. Schon (1983) reported in Tobin & Jakubowski said that when teachers become more reflective on their actions in the classroom, they begin to challenge the customs of the educational system and their own traditions of teaching. Reflection was itself named among the stages of knowledge construction (Etchberg & Shaw 1992:412) as being the making sense of gathered data - the learner relates the new information to what is already known, webbing the known and the unknown.

Yager (1993) reported in Bybee (1995:29) said that we must help learners develop perspectives of science and technology that include the history of scientific ideas, the nature of science and technology, and the role of science and technology in personal life and society. This development requires widespread acceptance and agreement among science educators. Consensus is also required in the teaching and curriculum development. Processes of science such as observation, inference, hypothesis and experiment have to be encouraged.

5. CONCLUSIONS AND RECOMMENDATIONS.

5.1 Conclusion

The problem is that transformation as defined in Chapter 1 is not taking place. What is claimed to be transformation appears to be cosmetic changes that were more focused upon the removal of discrimination between South Africans. One of the reasons that is delaying transformation in education is lack of transformation in society. Hence the failure of OBE will originate from the fact that it was introduced in a society that is still strongly modernist.

The problem is also that changes in the political scene are not in rhythm with the changes in laboratories. It is as if life in the science classroom is totally divorced from the political decisions in parliament. The need for transformation as defined by Ferguson is not the debate. If not needed to urgently reverse the effects of the CNE, FP and racial demarcation, transformation is a natural part of humanity. Each human being should be given a chance to become an open system. Thus critical debate concerns creating an environment that allows each person to explore and practice science freely. This requires defining the transformation process in terms of community needs and performance indicators towards achieving those needs. It also requires the involvement of all role players.

Science education is working in a society that has made the importance of science a rhetorical discussion. The Year of Science & Technology, for instance, did not leave a lasting impact – it was just another event that science students in some schools in Butterworth Region did not know about.

There may be not much gain in emphasising the paradigm that has to be applied in the process of transformation. After all paradigms are nebulous and many could not have worked in the majority of South African communities. Instead, more research in science education is required to establish the teacher's current problems and approaches in the science classroom. For example, transformation in science education may have to start with retraining teachers to become reflective practitioners. That is, teachers should be able to give sound reasons why they teach something and why they teach it that way. Thus transformation should be needs driven via critical thinking and problem solving. Priorities include hunger, unemployment, science & technology literacy, resource management and resource allocation.

OBE could answer to South Africa's curricular problems. Nevertheless, OBE should not be taken as a finished product but as an idea or foundation for further curriculum development. Fortunately OBE is inherently transforming and can evolve along with the needs of the people. For that reason, OBE as an organism should be nurtured through research that will involve teachers and learners as the main researchers.

Education and transformation ought to work together. However, education has traditionally been a conservation of values. Transformation and conservation may be contradictory. There is therefore a need to revisit OBE to find ways by which cultural values can be accommodated in OBE. The successful integration of Curriculum 2005 into peoples' lives and cultures requires further research otherwise the new curriculum will be seen as handed down and as a threat to culture.

Science is a major role-player in any transformation since much of the development employs science and technology. However, scientists are often managed and are still to assert themselves into leadership roles. The survival of science requires finance and finance can best be acquired if scientists themselves learn how to market and manage science projects and findings. However, the process for the transformation of science education is not clearly defined. Although a few suggestions are given here no one seems to be particularly concerned about education of Natural Sciences.

Of particular concern is biological science whose proportion in curricula seems to be diminishing. The other branches of science inevitably require an understanding of biological systems if the environment and people's lives are to be safely protected. There is a tendency to consider biological systems lastly in all technological developments. For example, developments in computer technology rarely prioritise human characteristics.

5.2 Recommendations

- Knowledge explosion requires a dynamic science curriculum that can accommodate new developments in science; a curriculum with greater relevance to local needs and contexts but taking into account recent discoveries and technologies is needed. That curriculum should be therefore learner centred and should result in outcomes that learners can perform. Furthermore, as with Swift’s (1992) recommendations (in Lubben & Campbell, 1996:311), a technological component of the science curriculum, including indigenous technology, may increase the relevance of learning and innovation.

- Science has to be re-invented in terms that are intelligible to each community and its language. Science has to be utilisable and be used to solve community problems. The link between science and traditional methods has to be worked at. There are probably useful traditional frameworks that can enhance the understanding of science. For example, M.Ed. candidates may have to visit local communities around their places of work and find out how Curriculum 2005 can be focused upon community problems. Tertiary institutions have also to design out-reach projects through which they will interact with communities. This will narrow the gap between science education and community needs.

- Computer literacy should be part of all courses. Computers have made more knowledge accessible. It is therefore better to teach people how to acquire and process that knowledge than to learn that knowledge. One of the resources that is important in processing skills is the computer. In the near future, it will be imperative for every person to be linked to the Internet.

- Transformation in science education should involve the inclusion of skills in management, particularly financial management, in the science curriculum so that scientists can manage their findings profitably. This will enable scientists to fund, manage and market their research.

- Science and technology literacy has to be improved. Science and technology ought to be studied as core subjects up to Grade 12 so that the public is well informed to handle new developments and to harness their environment. The public requires to be protected from 'scientific' advertisements.

- The future M.Ed. (Science Education) courses may have to involve investigations in traditional science-related beliefs. After all, learners come to school with their traditional beliefs. For the moment, scientists still graduate with myths surrounding their traditions. It is when science recognises some of the traditional methods or tries to offer explanations and easier alternatives that the 'majority' will take part in meaningful transformation of science. Rather than religion, that approach is more likely to counter the myths that are often called 'magic' or 'witchcraft' among Black cultures.

- Tertiary institutions ought to reach out and understand aspirations of people. Ordinary people should not look at tertiary institutions as ‘ivory towers’ that are alienated from community needs.

- Recommendations by Urevbu (1987:3) include that science should start from the practices of teachers and students in classrooms rather than idealised notion of the scientific method; science should be taught as a major human activity, which explores the realm of human experience. Furthermore school science textbooks should focus attention on the lives of the learners and should help create pupil’s awareness of the extent to which concepts, principles and generalisations are related to everyday life. Traditional African cultures should be properly explored and interpreted so that they can be of value to society. Certain cultural elements in the African situation may well impinge directly on the way in which an African can appreciate science.

- Cole (1975) reported in Urevbu (1987:11) raised the question whether there were facets-cultural, scientific or material – of this environment on which truly scientific training could be created, and suggested that we should begin to recognise the elements of many fundamental scientific principles embodied in some of the so called crude practices within African culture. Cole believed that the traditional African culture, if properly explored, held a rich source of materials for developing the ‘scientific method’ of inquiry and knowing about the various elements and processes in the African environment.

- Rollnick & Rutherford (1996:91) showed that the use of vernacular served several important functions including articulation and elimination of alternative conceptions, clarifying of concepts and formulating ideas. Ogunniyi (1996:280) advised that efforts should be placed on making books more readable, especially as students rely heavily on textbooks. The writing of science texts in mother tongue might help to minimise the influence of the so-called hidden curriculum as well as help to convey the intended meanings in a way more familiar to the students.

- More practical approaches can minimise rote learning. The government and NGOs should consider provision of apparatus and training teachers in practical skills more seriously.

- Science teachers need to become reflective in their practices. That is, teachers ought to change their practices in the classrooms with learner's participation. As Naidoo, Brookes & Pillay (1993:21) put it, educators need to identify more fully what it means to be a reflective practitioner and to determine the nature of underlying shift of attitude and paradigms.

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TOPIC 4

MY EXPERIENCES IN RESEARCH: A SOCIAL PROCESS THAT INVOLVES DISCOURSE AND POWER RELATIONS.

MY EXPERIENCES IN RESEARCH: A SOCIAL PROCESS THAT INVOLVES DISCOURSE AND POWER RELATIONS.

Abstract

Research helped me to reflect on my teaching practice. Unfortunately, there were interesting observations that fell outside the scope of my research topics and out of the accepted research norms that were not reported. I therefore argue that research has to be a bit freer and holistic in approach and in reporting.

I also found that my research activities comprised of discourse between supervisors and other candidates at the university as well as the teachers that were researched. Consequently results were significantly influenced by inputs of each role player in the research. All inputs displayed power relationships and interests of each role player through discourse. Discourse and its analysis was therefore an important factor in all aspects of my research.

Furthermore, although discourse correctly served Social Constructivism and improved the relevance of the research exercise, procedures that were inevitably based upon certain beliefs about the current problems in science education could have significantly swayed research outcomes towards expected views or criticisms about science education.

From the research results and experiences, I propose that further research on the processes that learners and teachers undergo in interacting with, and understanding

i) the researcher as well as the research processes, and

ii) the need and use of a selected sample of science apparatus

is necessary. The results that I obtained could have been influenced by either or both of these two interactions.

I base my discussion about discourse upon the writings made by Michael Foucault who is variously reported by different writers, such as Mphahlele (1996) and Jary & Jary (1991). Foucault described discourse, as ‘any structure of knowledge which determines the way in which the world is experienced and seen’ (Jary & Jary, 1991:196). Further reports of Foucault (1970) appeared in Mphahlele (1996:239) that the production of discourse is at once controlled, selected, organised and redistributed by a certain number of procedures. The desire to be unrestricted and the institution’s desire to control it constitute discourse, according to Foucault. Mphahlele believed that the latter happens through the application of rules and regulations, which delimit field, and methods of study. Mphahlele continued that these rules and regulations make it difficult to think outside them, because to think outside them is to lack the ability to satisfy the requirements of the discourse, and eventually of the qualification that the candidate desires. Rules and regulations are in this way linked to the exercise of power and control. Thus a discourse is both an instrument of power and a potential starting point for criticising that power.

Rhodes University, like many other institutions, has rules and regulations, which define what knowledge is, and how and by whom it must be produced and controlled. Much of these definitions are delivered through discourse. For example, there are lecturers and supervisors who not only guide candidates in research procedures, but also make sure that candidates have the necessary knowledge to carry out research. These lecturers define the qualifications and knowledge that must be possessed by candidates. Thus, although there were serious negotiations about standards and procedures, as well as a degree of freedom to chose methods, I had to learn about research as perceived by Rhodes University. There was nothing wrong with this, only that it emphasised the influence that an institution and its personnel have upon a research student, often through discourse. The need for the supervisor to further analyse and re-interpret my research plan and findings appeared to be part of a process of integrating, rejecting or accepting knowledge obtained from the research within the framework of the university’s standards, rules and regulations.

According to Robottom & Hart (1993:598), procedures control and delimit the research discourse, and include, among other things, aims, methods, techniques and instruments of research. For example, contrary to the institution’s desire to inculcate freedom of thought and thesis among its candidates (and may be among its lecturers), this approach is instrumentalist in implying that the interpretation of research-based knowledge is often from the academy to the candidate, and then to the researched (often teachers and students). The approach is also objectivist, according to Robottom & Hart, in that it suggests a universality of applicability of such interpretations, as well as research methods. That is, this approach speaks for all, candidates, teachers, students etc, regardless of their historical, social and political predicaments. Thus, candidates are not really free from their institution to establish a research procedure that does not commit itself to methods and paradigms favoured by that institution. However, the approved methods and paradigms can be foreign to contexts in which the research is done. Take for example, post-modernism - while it offers room for a variety of thought and critical reflection about one's actions, the context in the rural areas is still that of conformity to tradition. I think that institutions have a responsibility to study the societies they serve so that the gap in paradigms between institutions and society is narrowed as much as possible.

As Mpahlele (1996:246) pointed out, participants in the research process are individuals with unique personalities. There is therefore a reasonable chance that these personalities may fail to relate to each other, thus negatively affecting the research process. There must be a negotiated compromise. Negotiations happened in supervisor-candidate consultations, in forums and lectures involving the collective body of candidates and supervisors, in applying for permission from the Permanent Secretary of Education and in workshops during which participating teachers had to agree on the procedures and dates of the research. There was consensus in the majority of negotiations. However, in consensus and in cases where differences of opinions surfaced, each person tried to influence the research process towards his way of thinking. Some differences of opinion turned into submission or antagonism, depending on who held more power in the relationship.

Some of my research ideas were indeed disqualified through discourse. Earlier versions of knowledge, of research procedures and earlier beliefs on what was researchable limited some of my research options. The need to recognise these, unless I had very sound reasons to deviate, meant that I could not break new ground without demonstrating a mastery of contemporary research methods and knowledge upon which I would argue for a new ground. Yet there is no time and resources to challenge a theory or a method. Besides, mastering something in theory or in abstract is close to impossible.

Thus this research being my first in science education was a daunting (but necessary) task with so many unexpected events. As I read through literature, my thinking changed to follow the established methods, knowledge, rules and regulations. And the more I did research the more I seemed to be able to conform to contemporary practice in research. I believe that this following and conforming predetermined a significant proportion of the research outcomes and made research convergent rather than divergent – following certain rules and norms could have redirected research to expected results. By following rules in research, one is likely to obtain expected results. It is my view that rules, if followed verbatim, can trap a researcher into always validating earlier findings. Therefore it may not be surprising that results that radically deviate from earlier findings and contemporary beliefs may not easily be accepted. This is because the power of an individual researcher to break new ground or report unusual findings is apparently greatly curtailed by established knowledge and methods.

It was within the fear of deviating from ‘normal’ research procedures that much of what I saw and thought about during research, and my experiences in the science classrooms were not reported. I felt that these would be considered speculations and trivial, and would not be accepted, since such experiences fell outside the research questions and methods that I committed myself to in the research proposal. I even thought of rewriting my research methods to suit the unexpected reality that had not earlier on revealed itself during the preliminary survey. It appeared as if the findings from the preliminary surveys were not adequate. For the adequacy of the preliminary survey too is often judged against the norms of research and other people's experiences.

Apart from the possibility that the left-out observations may be of some relevance and may hide reality and context, already made methods and paradigms removed the excitement of finding out a possible ‘other’ method that can work. Research procedures require a definition of a research problem and method beforehand. Research lost some of the excitement when colleagues told me how to define a research problem and how to go about researching that problem. That is, some part of the problems that I planned to research ceased to be when I was told how to establish that these were indeed problems worth researching. Other people through discourse tried to live my experiences or to impose their interpretations of my experiences and expectations. (Of course language plays a role here since other people depend upon your use of language). I sort of got results before I started the research because I felt that the discourse about my research plans pre-empted the research activity. Thus agreeing about perceptions or problems at a certain level contradicts individualism and therefore contradicts individual preferences.

My research report gives the impression that my research was a smooth process without serious problems. An impression of a smooth research method justifies the choice of that method. Fraham- Diggory (1994) observed that subjects and experimenters must have done a great deal more than authors describe. Many research reports do not indeed report hiccups in procedure. I am therefore lead to question the honesty in research reports and think that research reports therefore have to be subjected to rigorous critical analyses. This is because a research report may have deliberately omitted some opinions, experiences and research problems in an effort to avoid antagonism against set methods and paradigms, or in an effort of the researcher to show that he is a good researcher. Thus the effort to make research conforming and objective may result in the loss of the richness of subjective speculations, thoughts and experiences. Some of my problems during research could have come out of following earlier research reports that recommended certain research methods that I used without illuminating critically upon the pitfalls in those methods. Thus Sanders (1996:296) encouraged science education researchers to open up their minds when it comes to interpreting data.

Against the apparent recommendation for consideration and inclusion of individual views and experiences during research, is the fact that much of education is a social event especially when it involves human relationships. The use of discourse and discourse analysis in my research was partly due to a desire to acknowledge the social nature of education. Discourse and social constructivism are necessary in such social events. It is thus a challenge for us to establish the point at and context in which an individual can be given the freedom to carry out research the way he thinks fit and at which collective concern through discourse and social constructivism has to determine the research methods and interpretations. The question is how much social constructivism and individualism should be allowed in research processes.

I think that discourse is also a means by which human beings enforce or respond to social rules and regulations. Research that I carried out on insects and plants earlier revealed that these organisms are predictable, even though they communicate variously. They base their actions or reactions upon natural instincts in the absence of discourse. Unlike other organisms, the human being can chose what to say and how to say it. Human beings can act and reason and so are very unpredictable. This unpredictability of human beings questions the truthfulness during discourse, and therefore questions the truthfulness of the results that I obtained (besides questioning the truthfulness of reportedly efficient methods of research). Unpredictability consequently questions validity and reliability of the research design and results that are related with humanity. It is probably in the same light that unpredictability rejects statistical models in human behaviour.

For example, teachers may have deliberately chosen to portray a desperate situation with their teaching even if they knew that the root of their problems lay somewhere else. This would perhaps attract sympathetic responses from the powers that are. The teachers could have perceived my research as a possible platform to relay a desperate picture through discourse during the workshops that planned the research and during interviews. They could have been aware that I had to plan my research the way they felt would be convenient to them and, that I had to write exactly what they said or report their exact responses to questionnaire.

Cohen & Manion (1989:253) defined discourse analysis as an examination of ‘accounts as they occur in context” According to Mphahlele (1996:240), these accounts include the candidate’s explanations of their intentions, beliefs, experiences and awareness of rules and regulations that govern the discourse. Discourse and power relations between teachers and me seemed to play a significant role in the interviews, reporting and interpretation of findings. In reporting and interpreting the findings I have a feeling that the teachers that participated in this research ought to have an opportunity to interpret the findings without reference to literature and institutional requirements. I think that the teacher’s perceptions and interpretations of science education are more ‘pure’ and realistic. After all we should not forget that all those that participated in this research held the teacher’s hopes that the research could lead to solving some of the problems in the teaching of science. Sander’s (1996) suggestion of a ‘rival hypothesis’ whereby the researcher takes the position of the researched teacher in interpreting findings and assessing research instruments is thus essential but should not be used without a critical analysis of the teacher’s and other participant’s interests.

On the other hand, re-interpretation of the teacher's responses can erode data of individual opinions, interests and differences between respondents. One of my interests was to find out whether some general trends could emerge from my findings. A general trend could then be statistically analysed against the 'normal' statistical curve. I was surprised to find that results were not that easy to record, summarise, report and interpret much as I tried to find out a pattern in them. Pattern seeking over-simplified reality. Since statistics works with summarised figures, statistics might not be useful in qualitative research designs in directing the researcher to valid conclusions. This is because human behaviour can not be mapped by a normal curve. Human behaviour may not obey statistical predictions because behaviour is contextual and unpredictable.

With the desire of looking for patterns, my research over simplified a complex situation due to a norm of producing interpretable and manageable data. My research focused on a few aspects of a complex education system. As a researcher I needed to make a report, a conclusion and recommendation from my findings. This need lead to the exclusion of the majority of factors, such as culture, language, economic standards and political affiliation could account for part of the difficulty in summarising, reporting and interpreting data.

The exclusions also came about by trying to describe my research in some form methodology and paradigm. For example, my research was claimed to be qualitative as opposed to quantitative, although numbers finally crept into the report when I wanted to know how many teachers made some similar statement. In this way my research experience fitted Robottom & Hart's (1993:593) view that to refer to the debate as being one of quantitative methods versus qualitative methods is to interpret the issue in simplistic technical terms rather than recognising its more complex ideological connotations. They believe that different approaches, theoretical assumptions, different ontology's (views of reality) and different epistemologies (different ways of knowing) all relate to ideology and politics.

Robbotom (1993:603) concluded that different approaches to educational research do not simply represent different strategies for data collection but rest on and express different ideologies that implicate different political arrangements and relationships among teachers, students, subject-matters, schools, support agencies and researchers themselves. Ideologies and political intentions of the teachers in relation to me as a researcher were implied in questionnaire about the teacher's responses and expectations from CASME. However, the teacher's political agenda in relation to students, Department of Education and between themselves were not researched although such ideologies could have influenced the results and altered the qualitative nature of my research.

The need to fit my research in a paradigm also meant that I had to plan and observe things from a position within that paradigm. This was a problem because the teacher's social-cultural context and my culture and beliefs were not probably described in the paradigm that I used. For example, I imposed a post-modern research approach in a culture that has its own rules and beliefs that are far from being post-modern. Secondly, I am not sure whether my judgement was without bias and interests – I believe that it is difficult to assume a neutral position that excludes my culture and subjective views of things. This implies that my (or any other) research reports may include, in subtle manner, subjective voices and judgements. The role of the researcher's culture, level of education and other personal aspects should not be under estimated in the design, reporting and interpreting research.

Unfortunately, teachers that I researched on did not know that I was operating my research in a chosen paradigm. And were they supposed to know? What are the legal and professional implications of the teacher's lack of knowledge of research paradigms and methods? These questions are important in judging the professional nature of my research, the appropriateness of my research questions or topics or even outcomes in the eyes of these teachers. The consequence is that my results and interpretations may not easily be understood and used by the teachers they are meant to help.

Conclusion

In my view, my research exercise was essentially a set of planned social events during which a discourse between me and other people that participated variously in the planning and interpretation of results took place. In all cases, there was an attempt by other role players and I to influence the process and outcome of the research, intentionally or not. In a nutshell, I conclude that research is a process that involves power played through discourse.

I learnt about research much more by practising research and about different instruments by using and triangulating between them. I think the research exercise was worthwhile and has motivated me to a desire for further research. My research experiences led me on to a different platform that has more questions than answers. I was lead to questions that interrogate research methods and practices in science education. The research practice has enabled me to criticise research reports in light of my experiences. It appears that research in science education need to be researched. I also think that the supervisors tried their best to inculcate as much independence as possible – they were open to different interpretations and ideas. But supervisors had to work within a university framework of time and requirements.

Results also showed me that there is still much to be done in improving science teaching, particularly in rural communities. This is because many of the assumptions about the teacher's understanding and use of science apparatus may be wrong. For example, my research assumed that teachers have no problems with using science apparatus and know all the equipment that they need.

It appears from my results that education planners and service providers such as CASME may be using wrong assumptions about the reality in science classrooms. A new database is required to prepare science education adequately for transformation to OBE. Further research is necessary to provide a framework for transforming science education to OBE, especially in rural environments.

It is however worrying that I could have obtained recommendations from incomplete research reports. Educational research being a social event uses discourse during which the design, method and interpretation can be subjected to a power play between role players rather than a genuine need to investigate the reality in classrooms. As Sanders (1996:297) stated, research validity goes beyond the validity of data-gathering instruments and refers to the researcher's explanations of what happened. Thus the researcher's and teacher's voices and freedom to express their views should be given more prominence if research findings are to be applicable by the researchers and teachers.

Recommendations.

I wish to proceed with the research that I started, but in the direction of identifying the sources of teachers' and learners' conceptual frameworks and approaches. For example, further research should be directed towards investigating upon what frame works teachers organise science lessons in rural classrooms. This requires investigating

- the interaction processes between learners, teachers and apparatus or other teaching aids, and
- The effect that the teacher's and learner's beliefs, environment, culture (and language) and perceived needs as well as problems have upon such interaction processes.

Research questions may include

- What happens when new apparatus is introduced?
- What do teachers and learners think of the apparatus?
- How do the teachers or learner's philosophies, knowledge and aims about science shape learning processes?
- Learner and teacher frameworks – what do they know that closely relates with the science apparatus, concepts and knowledge?
- What is learnt and how is it learnt?

These would fit in well with some of the factors that were identified as being critical in improving science education in Africa (Ogunniyi 1985, 1986, Prophet 1990, STAN 1992 all reported in Ogunniyi 1996:267). Among others, these included the teachers, the student, the school environment, and the home environment, the society and nature of the subject.

I think that the research instruments themselves are proper subjects of research. This is in agreement with Robbotom's (1993:603) recommendation for *a meta-research agenda in science educational research*, for research about research in science education. The research instruments that I used require further investigation because these could have biased my findings. Among other things, the research should continue with

- Researching the research instruments that I used,
- The paradigm that is operating at the schools where I carried out my research
- The interpretation of these instruments by the teachers,
- The understanding of statements in the questionnaire and
- The understanding of the video-recorded interview.

Research in science education has to be integrated with science practice in the classroom. This implies involving the teachers in setting the research question and procedure, without much respect to paradigms.

Hence, a holistic approach is essential because behaviour is integrated. The challenge of presenting ***all*** data with a more serious entertainment of teacher's interpretations and without attempts to look for trends or without generalising, remains one of the most crucial in research in science education, since each teacher and context may require different solutions. The ultimate aim would be to improve teacher's and student's performance.

There was time when I could not differentiate between research and science methods. Thus I recommend that science education should involve research skills because science methods are essentially research methods.

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South Eastern Region
NEEDLE WORK CLOTHING YEAR MARKS SCHEDULE FOR STANDARD 10

		GARMENT CONSTRUCTION																EMBROIDERY WORK					ASSIGNMENTS			PROJECTS					
	Name of Learner	Prep. Of pattern	Prep. Of Fabric	Placing & cutting	Constr. Lines	Stay Stitching	Seams & Tailored	Disposal of fullness	Sleeves	Collar	Lining	Interfacing	Facing	Hem Finish	Fastenings	**TOTAL/3**	**YEAR MARK**	Prep. Of Fabric	Scalloped Edge	Cut work	**TOTAL/3**	**YEAR MARK**	Assignment I	Assignment II	Assignment III	Project I	Project II	Project III	**TOTAL/60**	**YEAR MARK**	**GRAND TOTAL**
		10	10	10	10	5	20	15	15	10	20	5	20	10	20	180	60	20	20	20	60	20	20	20	20	20	20	20	120	20	100
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Teacher Signiture ***Date:*** ***Principal Signiture*** ***Date:***

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