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***"THE ROLE OF COMPUTERS IN EFFECTIVE
SCIENCE EDUCATION: A CASE OF USING A
COMPUTER TO TEACH COLOUR MIXING"***

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Abstract : Science education in South Africa is not improving much. Many science educators do not have appropriate science qualifications. Majority of the learners have limited facilities to learn science. In this dilemma the move to OBE may result in further substantial deterioration of science education. A possible way out is to use computers in science education to facilitate the learning process. This study was designed to investigate how computers contribute to learners' skills development in a physics course. A series of interactive computer simulations of colour mixing and a number of closely related traditional practical activities are aimed to promote learners' understanding of colour. It was concluded that while computer environments have greater potential as learning tools, they also limit interactions in significant ways.

1. Background to study

South African education is in a state of change. The Department of Education is trying to accelerate the pace of change but at the present time insufficient resources in many schools are the stumbling-blocks to this change. The ultimate goal of the Department is to implement outcomes based education. The OBE is based on a structure that begins by recognising the critical skills, knowledge and values that are important for all learners.

Education in South Africa has passed through many stages. None of these stages provided adequate resources to the majority of the learners. In the past, Education in South Africa has been segregated. The Apartheid ideology determined that there be separate education for whites and blacks. On the basis of this ideology, the state sponsored 14 departments of Education. Resources to these various departments were also discriminatory and were more inclined to favour whites with the Black population getting the least of these resources. Superiority could be easily detected in human, financial and other resources which were all highly concentrated at white schools.

The following table illustrates, the state expenditure during the Apartheid years.

Per capita expenditure on education in South Africa

Year	African	Coloured	Indian	White
1953-4	17	40	40	128
1969-70	17	73	81	282
1975-6	42	140	190	591
1977-8	52	185	276	657
1980-1	139	253	513	913
1982-83	146	498	711	1211
1984-5	227	639	1112	1702
1986-7	369	887	1714	2299
1988-9	656	1221	2067	2882

Table - 1

(The right to learn; Sources: Blignaut, 1981 and SAIRR surveys)

The effect of this segregated system was a scenario where white-schools were of higher quality and standards, built on large tracks of land, electricity, running water, well-equipped laboratories, facilities like libraries, sports fields with no overcrowding and highly paid and highly qualified educators. The result of this was high standards and high pass-rates in White schools, thereby getting opportunities to further studies in areas like Engineering, Medicine, Architecture, Accounting while the poor, overcrowded black schools could only attain poor results, thereby many dropouts, fewer further education career-lines and lower-ranks of employment as cheap-labourers. A final point, is that educators at black schools were not required to have had same level of training as those at white school. Many were totally underqualified for the jobs that they were mended to have.

Period of transition

In order to try and cope with the obvious discrepancies in the quality of education amongst the different race groups, in 1992 the government introduced different schooling systems, namely Model-C, Model-B. From the government's point of view, this would allow certain government-owned schools to become more autonomous, which would make more funds available to previously disadvantaged school. Parties in opposition to these models would argue that these models were merely introduced to maintain the imbalances in the South African society by keeping quality education under the control of the privileged few.

The differences in some important aspects are tabled below.

	Model-B	Model -C
State Funding	Equal amounts.	Equal amounts.
Staffing	Appointed by Education Department.	Selected and appointed by governing body.
Building Maintenance	Responsibility of the state.	Full responsibility of the parent body.
Pupil Admissions	Determined by the Education Department.	Determined by the school.
Outcome	Government fully responsible for the school, but has no money to look after it.	Besides government funding parent body control the running of the school, and are able to maintain a high level of education, as well as extramural activities.

Table - 2

(Nicolau, G. and Nicolau, E. The School Guide Book. Johannesburg G.E.N. publishing, 1998)

The Present Educational System

On paper, all pupils now have access to quality education. Unfortunately, due to language problems, as well as financial restraints, most people do not have access to these facilities. The government is forever upping the pupil to teacher ratio, not so as to bring disadvantaged communities into line with previously advantaged ones, but to put everybody into the disadvantaged category. Also, as far as the controversial Model-C schools go, more and more parents are not paying School fees (with the government doing very little to help these schools sort this problem out). As a result, national education currently appears to be a sinking ship.

Science Education in South Africa

Science has revolutionised the world such an extent that people can derive a lot of benefits which were not available to them in the past. Majority of the people in South Africa had long and still are being in a disadvantaged position in the field of science and technology education. As a result they did not derive most of these benefits, if not all, of this scientific revolution. Further the lack of science and technology education did not enable this disadvantaged community to empower themselves to become useful citizens leading a dignified life with self respect.

Science education is indispensable for every learner up to Grade 12. For a minority of the learners, school science education will be their first step to becoming scientists. The majority, will not continue to study science further. For them, science is part of their general education, to provide a gateway for life in a modern technological and industrialised democracy.

"The National Teacher Education Audit (1995), commissioned by the Ministry of Education, concluded that teacher training in South Africa was so poor that the entire system needed to be rebuilt. The report showed that training at 90% of the country's 109 colleges of education failed to prepare student teachers for the challenges of the new South Africa and the 21st century. The poor facilities and lack of adequately trained mathematics and science teachers at most traditionally African schools present considerable problems for the future improvement of mathematics and science education, particularly considering that the number of Grade 12 candidates is expected almost to double in the next 10 years."

(SA SCIENCE AND TECHNOLOGY INDICATORS -1996; page 19)

In South Africa, total of 1406513 physical science learners from Grades 10-12 were educated in 1994 by 5013 physical science teachers in African secondary schools. Only 3669 teachers are *qualified out of this 5013 teachers. Pupil - teacher ratio in physical science is approximately 243:1 while the national pupil-teacher ratio was 27:1 in secondary schools. (National Teacher Education Audit, 1995). The ratio will be worsened by the restriction in the appointment of new teachers, due to the lack of funds in the department of education now.

* A qualified teacher in South Africa, according to the official norm, is one with at least a Std 10 certificate (M) and a three-year professional qualification(M+3).

The need for change in science education is affirmed by the fact that, of the over 70,000 learners in the South African schools that registered for higher or standard grade physical science in 1994, just over 13000 or some 20 %passed(Department of Education data, 1995).

In addition, the recent Std 10 physical science examination results also show that the performance in the African schools is still poor. (Department of Education: Examination Result analysis: 95,96 &97). A consideration of the facilities available to the majority of the learners and the availability of sufficient adequately qualified science educators indicate that these could be some of the key reasons for such a high rate of failure.

A survey conducted jointly by the Foundation for Research Development and the Human Sciences Research Council in 1995 showed South Africans lagging behind most countries in scientific and technological literacy. In comparison with 19 other nations, South Africans ranked 18th out of 20 nationalities in their knowledge of the natural and the environmental sciences literacy (The Year of Science and Technology: Calender 1998; page 5).

If south Africa wants to face the challenges of the modern scientific world, rapid empowerment of the African learners in science is very essential, as the African learners are in the majority in the schools at present. Appropriate methods of learning and the resources are the keys to successful science education. They influence the development of learners' knowledge of, and attitudes towards science.

In this dilemma effective science teaching can address the question of quality science education in the schools. Overcoming such problems as low enrolment, poor performance and poor international standing, in science education, raises the important question as to how effectively can we improve science teaching in a short time. Effective science instruction may motivate the learners towards science education and it can produce scientists and science educators needed in this country.

Computers in Science Education

South Africa is not unique in having poor performance in science education - indeed the United States of America is also concerned about the inferior performance of its young people in science and is searching for a new educational paradigm. A possible solution lies in the appropriate use of computers in education and President Clinton has made the provision of necessary computer resources in schools as one of the goals of his presidency. (Starr, P., 1996)

“The use of computers in education has been widely suggested as a possible solution to the considerable educational problems which face South Africa”(Sewell,B.T., and Buirski-Burger, N. 1998). Any possibility concerning the introduction of computers into education must address the question of whether they assist the learners in the learning process. It is the duty of the concerned science educators to explore benefits from the introduction of computers in science education.

The initial phase of my research involved the review of literature to ascertain the uses of computers in the science classroom. The literature supports positively in its assessment of the effects of the use of computers in education. For instance, in his meta-analytic studies, Kulik (1994) reports:

- C Learners usually learn more in classes in which they receive computer based instruction.
- C Learners learn their lessons in less time with computer based instruction.
- C Learners like their classes more when they receive computer help in them.

During recent years, public education in many countries has been transformed through technology. Countries where out comes based education has already been introduced, are investing heavily in technology to move computers into school classrooms. “Driven by government commitments to finance the connection of schools to the Internet and purchase of more computers for classrooms, education departments around Australia are optimistically projecting that basic literacy will be integrated in school curriculums in the very near future”(Education Queensland : 1997). South Africa has already implemented the out comes based education in the foundation phase. Can our learners benefit from the

introduction of computers into our science curriculum?

Bearing the above in my mind, I have carried out my research in a rural school in South Africa. Selected participants performed two sets of experiments by mixing the colours in different proportions. One set was performed with the use of a computer and the other by traditional methods. The whole procedure was captured by a video camera to analyse the events repeatedly if necessary.

Designing Teaching Experiments

The proposed study, introduction of a computer for a teaching experiment in physics, involving students aged 15 to 18, main features of which are discussed in Chapter 3, which I carried out at my school. The disadvantaged school situated in the Ginsberg location, 2 km from the King William's Town city-centre, is a former DET school with 100% enrolment of black learners. At this point, I would like to give the background of the science department of the school.

Educators and learners in Physical science, General science, Biology and Agricultural science form the science department. There are six educators in the science department including one head of the department. Only the head of the department of science is qualified (degree + diploma) to teach science, other educators do not have physical science or general science as majors in their Senior Teachers Diploma. In my School 119 learners are taking physical science as a subject in Grade 10, 11 and 12 out of 986 learners. In the previous years, according to our school policy, we admitted students to do science in grade 10 only on merit. The best 35 learners were selected from Grade 9 on the basis of their end of the year examination performance in the physical science component of general science and mathematics. When they fail physical science in grade 10, they were changed to other subject combinations in the same grade. New admissions to science in grade 10 are strictly on the basis of very good performance in an aptitude admission test. For the last two years, under the new school policy, no such criterion for selection was enforced and learners from our school as well as from other schools were allowed to do science according to their own choice. This freedom of choice for the learners has raised the pupil-teacher ratio. Though the school is situated in the urban area, most of the learners in the science classes do not have proper foundation for science learning. Basic concepts in science are unknown to them and none of them had any experience with computers. Even the educators in the science department never had experience in operating computers.

The main part of my study was to find out the skills development, and the participants attitude towards the computer, when they are exposed to the computer. An observation schedule and a survey on learners attitude towards the experiments were used to gather quantitative data. Questionnaires and focussed interviews were used collect the qualitative data. I have chosen to use these methods because they will enable me to obtain accurate quantitative and qualitative data without any bias.

Findings from this study indicate that the use of computer provides opportunity for the learners to develop many skills and a rich learning experience. With proper implementation, computer technology can transform the classroom and create a superior learning environment. Findings also showed that the learners needed only a few basic instructions at the start to use the computer in their experiment after which they were able to proceed without much assistance from the teacher. Computer-based experiments change the learners' attitude in a constructive way and create interest in science learning.

2. Literature Review

My research mainly focusses on learners' skills development and their attitude when they perform experiments with the use of a computer. Curriculum 2005 emphasis the two key aspects of skills development and attitude. Further, curriculum 2005 has been implemented in the foundation phase and it is going to be introduced in other phases soon. So, it is important to review some curriculum 2005 literature to uphold my research.

Curriculum 2005

The process of review and renewal in South African education began in August 1995 in response to the need to normalise and transform teaching and learning in a new democratic South Africa. From the outset, emphasis was placed on shift from the traditional content-driven approach to outcomes-based education. It was announced that a new curriculum would be phased in Curriculum 2005. A technical committee was appointed by the Minister of Education to produce a discussion document containing the core of the new South African curriculum.

By January 1997, eight committees representative of the eight learning areas that will form the basis of the new South African Curriculum had developed rationales and outcomes for each of their respective areas, namely:

- C Language, Literacy and Communications
- C Mathematical Literacy, Mathematics and Mathematical sciences
- C Human and Social Sciences
- C Natural Sciences
- C Technology
- C Economics
- C Arts and Culture
- C Life Orientation

The outcomes-based curriculum is based on a structure that begins by recognising the critical skills, knowledge and values that are important for all South Africans to acquire. These are expanded into specific outcomes in each of the eight learning areas. Learners will need to show evidence that they have achieved these specific outcomes. This will be done by means of assessment criteria and range statements.

(Curriculum 2005: Department of Education: April 1997)

The process of science, Specific Outcomes 1, 3 and 4 in Curriculum 2005 Natural Sciences Learning Area, will be the main focus of this study, which is needed to our learners to face the challenges of the rapidly changing science-world and to mould them to fit for the 21st century. In detail we will view the contributions of the above experiments in the development of problem-solving and decision making skill, investigating skill, communication, and the avenues such as attitude towards the computer, confident in handling the instruments, enjoyment and play.

My research is in science education. I felt to include some benefits of science education from literature.

Science Education

The need for empowerment for the disadvantaged community in South Africa can also be viewed from the perspectives of the arguments of Robin Miller:

“The economic argument: that there is a connection between the level of public understanding of science and the nation's economic wealth. In addition, scientific and technical achievement is seen as a sign of a nation's international standing.”

“The utility argument: that an understanding of science and technology is practically useful, especially to anyone living in a scientifically and technologically sophisticated society. They are better equipped to make decisions about diet, health, safety and so on. They can evaluate manufactures' claims to make sensible consumer choices.”

“The democratic argument: that an understanding of science is necessary if any individual is to participate in discussion, debate and decision-making about issues that have a scientific component. Decisions have to be made about transport, energy policy, testing of drugs and treatments, disposal of waste, and so on. There should be public accountability about the directions of some scientific research, and public involvement in decisions about whether or not to apply such knowledge.”

“The social argument: maintaining links between science and the wider culture is important.”

“The cultural argument: that science is a major - indeed, the major - achievement of our culture and that all young people should be enabled to understand and to appreciate it. We should celebrate science as a cultural product.”

(Robin Millar, Science School Review, March 1996, page: 9)

In this section I refer the findings from other researchers of the use of computers in science education. There are many parallels between their researches and mine; however there are also significant differences in the usefulness and applications of using computers in science education. It is highly relevant to include them in my literature review.

Computers in Science Education

Computer technology in the science classroom is very broad. The manner in which it can be applied is limited only by our creativity. Historically computer technology was first applied to education for drill and practise with a focus on helping learners memorise or practise skills that required rote memory. There after developers tried to make the computer become an automated teacher with tutorial software. (Starr, P. 1996)

Since the out comes based education does not support rote memory and automated teaching neither can be accepted well by learners. The most exciting use of information technology in the science

classroom would be tool-based applications, meaning learners can use the computers in the classroom the same way practising professionals use technology. 'Real world' software solutions can usually be classified as tools for the access to information, manipulation of information, or for the communication of information.(Turkle, S. 1997)

Within this framework the following benefits are discussed in detail.

C The use of computer technology provide opportunities for sophisticated inquiry investigations, especially those are not possible because of time, expense, safety or environmental constraints. Computer based simulations and modelling tools help to remove constraints of time, safety, expense and even allow manipulation of variables normally out of our control. The power of computer interactive visualisation tools will provide learners with real worlds to manipulate.

C When used appropriately, computer technology in classrooms stimulates increased teacher/learner interaction, and encourages co-operative learning, collaboration, problem - solving, and learner inquiries.

In computer -rich classrooms, educators interact differently with learners, acting more as guides or mentors and less as lecturers; team with other educators; and work across the curriculum. With computers, learners co-operate and collaborate more with their peers. Educators and learners are free to explore problem-solving, creative thinking, and expressive writing and speaking.

C Computer- based instruction is especially effective among weaker learners. The benefits of computer technology are especially notable for learners who are likely for school failure. The use of computer can be less threatening to a learner who has already experienced many failures in traditional classrooms situations. Assessments have revealed that computer-rich programmes raising their scores.

C Learners from computer-rich classrooms show better behaviour, lower school absentee rates, lower drop-out rates and earn more college scholarships.

When the opportunity to use computers is given to the learners , the active participatory role in learning increases. As a result, self esteem is enhanced, and attitudes toward school improve. The strength of technology provides an excellent platform where learners can collect information in multiple formats and then organise, link and discover relationships among facts and events.

(Kulik, J., A. 1994)

Integrating computers into teaching and learning faced many difficulties in schools. Reasons for these difficulties are listed below.

1. Teachers lack expertise and they lack the time to learn how to use computers.
2. Teachers are inadequately trained to use computers in their classrooms.
3. Learners and teachers do not have adequate access to computers.
4. Teachers fear for change. Teachers either feel insecure with technology or they fear that the computer will expose their lack of subject knowledge.

(Sewell,B.T., and Buirski-Burger, N. 1998)

The main part of my research was to focus on skills developments. An observation schedule was prepared to determine the skills development. Problem-solving & Decision making and Investigating skills are cited here. Since the recognition of skills development is not in the present curriculum, the following literature review was very useful to the observers and me in classify the skills.

Problem-solving & Decision making skill

In mathematics and science, the word problem solving has frequently been applied to cognitive, written problems. Its place in science education has been reviewed by Garrett(1986), who mentioned in his paper: ' As Sham (1976) has pointed out, the whole field of endeavour in problem-solving is particularly vast and largely disorganised and this has been shown to be true even in the limited area of science education'. (Investigating work in the science curriculum: Richard Gott and Sandra Duggan: 1995, page 41)

Watts and Gilbert (1989) suggest that there are wide variety of problem solving tasks which emerged in the late 1980s, have grown out of search for means of making science relevant and of allowing pupils to apply scientific principles. These tasks can be either written or practical but have a strong emphasis on skills and methods and include puzzles, design-and-make activities, and extended project work.

A basic, and deliberately simplified model for science based on epistemological perspective, which seeks to define the problem-solving, advanced by Gott and Mashiter (1991) will serve as a diagrammatic starting point.

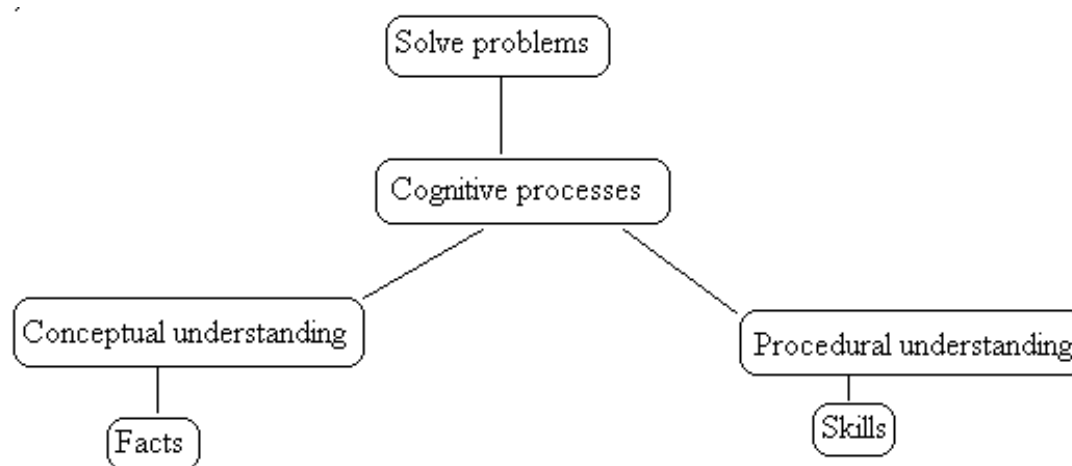


Fig 1
A model for science (based on Gott and Mashiter, 1991)

A descriptive model primarily to consider the aspects of performance and appropriate to assess was developed by the Assessment of Performance Unit (APU) which was set up by the Department of Education and Science (DES) in UK The model provides (Fig 2) a more detailed description of what is going on when pupils are engaged in the problem- solving activity.

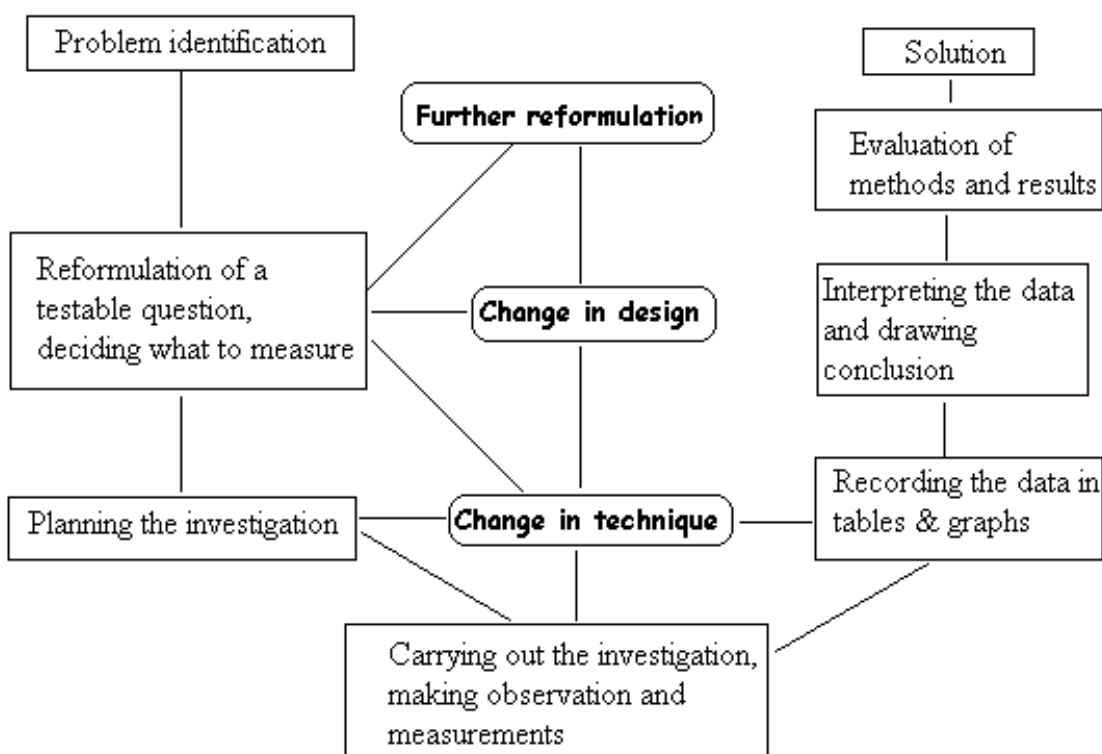


Fig 2
A model for problem-solving activity (Gott and Murphy, 1987)

Investigating skill

"Perhaps the feature of school science which most clearly differentiate it from other subjects of the curriculum is that science classes take place in laboratories and involve students and teachers in carrying out practical investigations and demonstrations Exploring and investigating is central to the work of scientists and to science education"

(Robin Millar:(1989) Doing Science: Page 38)

"Investigation provides opportunities for pupils to use concepts, cognitive process and skills to solve a problem. It usually offers several alternative ways of reaching a solution to the problem and the skill can be categorised as:

1. Using symbolic representation.
2. Using apparatus and measuring instruments.
3. Observation tasks.
4. Interpretation and application.
5. Planning of investigations.
6. Performing investigations."

(Robin Millar(1989): Doing Science, Assessment of Performance unit - 1985)

3. Methodology

The main objective of this research is, to find the skill developments, and the users attitude towards the computer, when a computer is introduced to carry out an experiment. Both quantitative and qualitative research methods were used in gathering data. The quantitative data was collected from a direct observation schedule (Appendix -ii) used by the observers, and as a survey on learners attitude towards the experiments (Appendix - v). Open-ended questionnaire for learners (Appendix iii) and another one for educators (Appendix - iv) together with focussed interviews were used to collect the qualitative data. As open-ended questions allow for free and flexible responses, it will enable me to probe deeply to achieve the objectives of the research. Questions were carefully formatted in simple English without any ambiguity and not to irritate learners and the educators. I drafted the questionnaire and tested with my co-learners (with whom I was studying the M. Ed course) there after with their input I modified the questions before they were given to the respondents. Much of the information was gathered from the questionnaire, because it is anonymous and reliable, it encourages greater honesty. I used the focussed interview because the respondents in my research are exposed to both experiments and also I thought their responses may be used to validate hypotheses.

For this research I selected eight physical science learners from Grade 11 and two educators from the science department. Four of the learners are males and the other four are females. The learners were selected on the basis of their performance in physical science. Four of them are very good, two of them are average and the rest of them are below average. Four learners can communicate in English very well. Since I have been teaching these learners from last year, I did not find any difficulty in selection for my research sampling. I planned for a non-probability, purposive sampling survey to avoid complications in my small-scale survey. Small-scale surveys often resort to the use of non-probability samples because, despite the disadvantages that arise from their non representativeness, they are far less complicated to set up, are considerably less expensive, and can prove perfectly adequate where researchers do not intend to generalize their findings beyond the sample in question or where they are simply piloting a survey questionnaire as a prelude to their main study (Research Methods in Education: Cohen and Manuel, 1994, page 88). One educator in my selection is a male and the other one is a female. Both of them are teaching general science in my school. When I considered the sample sizing, the eight learners make 25% of their class population of 32, which is reasonably good for my research.

As I planned, at the start, the learners were trained in the basic operations of the computer, in groups, and the educators were trained individually at their request. To keep variation to a minimum, prior to the beginning of the experiments, learners and educators participated in the same training at least two hours. First they learned the specific commands and procedures of the word perfect and applied them in various situations. These included the functions of cut, copy, paste, save and managing files. Learners spent their after school hours on the computer and the educators used their free time to learn the operations.

Colour mixing is the main feature of the experiment. It was planned to be carried out in two

separate ways. One is our traditional way of conducting experiments and the other one is mixing the colours with the use of a computer. I selected this topic for the following reasons.

1. I wanted to carry out the experiments in my school. The computer available for this research at the school has only the word-perfect programme. Designing the colour mixing in the word perfect is quite simple and it does not need any expensive software.
2. The resources for mixing the colours in the traditional way are also easily available in the school.
3. The learners selected for my research, already learned this topic.
4. Learners always show interest in playing with colours.

Though, the learners learnt the topics of Concept of colour, colour mixing and the spectrum, last year, I planned to include the explanations of the following prior to the experiments to refresh them in colour mixing.

Colour : The sensation produced when light of different wavelengths falls on the human eye. The visible spectrum covers a continuously varying range of colours from red to violet it is usually split into seven colours (the visible spectrum) known as red, orange, yellow green, blue indigo and violet.

Primary colours: Any one of a set of three coloured lights that can be mixed together to give the sensation of white light as well as approximating all the other colours of the spectrum. The spectrum may be divided into three primary colours known as primary blue, primary green and primary red.

Colour mixing: Different colours are produced by varying the proportions of the prime colours. Combining coloured lights is an additive process.

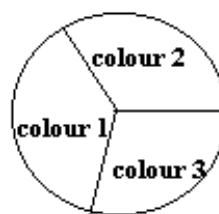
Plan for traditional way of conducting experiment

1. Material for learners

Booklets on theoretical contents, colour paints, electric motors, circular discs as shown below with word sheets and exercises.



Disc for mixing two colours



Disc for mixing three colours

2. Training

Learners were trained to

- (a) paint the water colours on the discs provided.
- (b) place the discs on the electric motor to observe the

resultant colour.

3. Experimenting in class

Learners performed the experiment as a group (two learners in one group) according to the topic organisation. Educators performed the experiment individually.

Procedure

- (a) discs were coloured by different prime colours in different concentrations
- (b) dry coloured discs were placed one by one on an electric motor.
- (c) resultant colour were recorded when the disc is in rotation
- (d) recorded discs were stored in the laboratory for future references

4. Observation of learners' / educators' reaction.

Observation of the behaviour of the learners / educators during the practical work.
(Possibly by a video camera)

Creating a "learning opportunity chart " for various skill developments against time.

Analysis of completed questionnaires from the learners and educators.

Plan for conducting experiment by using a computer

1. Material for learners

A computer with colour monitor and The word perfect soft ware.

2. Training

Learners and educators were trained (a) on the basic operations of the computer
(b) to use the colour palette under the font.
(c) to save and retrieve the files.

3. Experimenting with the computer

Learners performed the experiment as a group (two per group) and the educators performed the experiment individually.

Learners and educators performed the experiment as follows.

- (a) opened the computer and go to the word-perfect 6.1 programme.
- (b) selected the font under the highlighted format
- (c) selected the colour palette 256 under the font
- (d) mixed the prime colours in different proportions in the 0 - 256 scale.
- (e) found the proportions of the prime colour components in a given colour
- (f) saved the files for future references

4. Analysis of learners' / educators' reaction

Observation of the behaviour of the learners / educators during the practical work.
(Possibly by a video camera)

Creating a "learning opportunity chart " for various skill developments against time.

Analysis of completed questionnaires from the learners and educators.

Great emphasis was given to the observation procedure throughout the experiments. The whole experiments were captured by a video camera. The process was recorded by a video camera for the following reasons.

1. The experiments were performed by the four different groups in four different days. Each day, there were two sessions, one of 50 minutes and another one of 30 minutes. The observers made it clear that they may not be available all the time.
2. In each experiment there were eight aspects to be observed and the number of observations of each aspect was also to be recorded. It was thought that observers may not be able to do this effectively during the time the experiment was performed.
3. As a recorded video tape can be replayed any number of times, it gives ample time for observers to discuss the relevant aspects before reaching a conclusion.

EXPERIMENT 1

Learners were grouped as follows:

Group 1: Two female learners of which one is a good performer and the other is a weak performer.

Group 2: One male learner who is a good performer and one female learner whose performance is average.

Group 3: Two male learners of which one is a good performer and the other is a weak performer.

Group 4: One female learner who is a good performer and one male learner whose performance is average.

Note : Each group got at least one learner who is fluent in English.

Each group of two learners took approximately 50 minutes to perform this traditional way of mixing the colours. Except in the extreme difficulties learners were allowed to do the experiment in their way. Learners were not trained or demonstrated how to proceed the experiment as planned earlier but clear instructions were given prior to the experiment. One sample disc was given to them and they were instructed to cut as many as they want from the white sheets by using a pair of scissors. Learners were not active enough to deal with the problems, they faced during this experiment. Time was wasted in unwanted activities such as drying the water colours. First group took 15 minutes to put one painted disc on the motor! Learners did not paint the discs clearly, the brush was not washed before they touched the second colour. They painted the laboratory and their clothes with the water colours. In some instances learners noticed that the disc was stationary while the motor rotates. Learners had difficulties in observing the colour of the rotating disc as it was

vibrating because of the high speed of the motor. They did not take any precaution to reduce the speed of the motor.

First group used only four discs. They painted the discs with the same concentration of colours. Their discs appeared with blue + red, red + green, green + blue and blue + red + green colour combinations. This group was assisted frequently by the educators.

The other three groups relatively performed the experiment well. Second, third and the fourth group used 8, 11, 9 discs respectively. These three groups changed the concentration of the colours in different proportion and observed the resultant colour. These three groups were seldom assisted by the educators.

All the four groups wrote the observed resultant colours on the back of each disc for their future references. All the eight learners in the four groups performed this experiment 1 in four different days. Two general science educators observed the process. The whole experiment was recorded on a video cassette.

EXPERIMENT 2

The same group composition, performed the first experiment continued the second experiment. Learners performed this experiment as an after school activity. Each group of two learners took less than 30 minutes to complete the experiment with the aid of a computer. All the groups mixed the combinations of the prime colours such as green + red, green + blue and blue + red in the maximum concentration (scale of 256) and recorded the resultant colours at start. Thereafter they changed the concentrations of the prime colours numerous times in different proportions to get different colours. When using the computer, all the four groups, opened files for saving their record of observations and findings for the purpose of retrieving when necessary. The groups two and three also recorded in their files, a comparison of the observed resultant colours from the results of the two experiments.

They also found the concentrations of the prime colour components of a given colour. Throughout the experiment, the learners did not request any assistance from the subject educators. Two educators also performed this experiment individually. The whole experiment was recorded on a video cassette.

At the end of these two experiments structured questionnaires were given to the learners as well as to the educators and they were interviewed too.

4. Results

This chapter views, in detail, the contributions of the above experiments in the development of problem-solving and decision making skill, investigating skill, communication, and the avenues such as attitude towards the computer, confident in handling the instruments, enjoyment and play.

Problem solving and Decision making skill

The literature review guidelines helped me and the observers to formulate exactly what we are looking under the problem-solving skills. The core problem, learners faced in both experiments was mixing the prime colours in different concentrations.

There were numerous science related sub-problems cropped up in the process of both experiments. The following sub-problems were noted by the observers in the experiments.

Experiment 1

1. Cutting the discs: Learners thought all the discs should be the same size.
2. Selecting the colour: Adding water is needed to change the concentration is not known.
3. Drying the paint: How to dry the paints in a short time is a problem.
4. Placing the disc on the motor: Pricking the discs on the top of the motor made the hole larger at the centre of the disc.
5. Not rotating disc: Due to the large hole at the centre of the disc.
6. Vibrating disc: Light disc and the high speed motor created the problem.
7. Observing the resultant colour: Many factors to this problem
8. Storing the discs: Quick sorting is important in limited space.

Experiment 2

1. Opening the desired programme: Computer operation with the mouse is a problem.
2. Changing the concentration of the colours: Using the 0 - 256 scale in the computer.
3. Getting the resultant colour: Using appropriate computer operation.
4. Identifying the colour: Comparing the given colour with the colour on the screen.
5. Saving the resultant colour: Using appropriate computer operation.
6. Retrieving the saved colour: Using appropriate computer operation.

The following tables illustrate the findings in the problem-solving and the decision making skill developments.

Core problem-solving activity in Experiment 1 (50 minutes)

Group	Defining the problem	Choosing the method	Arriving at solutions	Frequency per minute
1	4	3	3	0.20
2	6	4	4	0.28
3	5	5	4	0.28
4	6	5	5	0.32

Table - 3

Core problem-solving activity in Experiment 2 (30 minutes)

Group	Defining the problem	Choosing the method	Arriving at solutions	Frequency per minute
1	12	12	12	1.20
2	19	18	18	1.83
3	14	14	14	1.40
4	13	13	13	1.30

Table -4

In the above tables illustrate selecting the prime colours in different concentrations as defining the core problem, the process of mixing the colour as the method and observing the resultant colour as arriving at solutions(decision making). The numbers in the columns are the events seen in the video replay and agreed by both observers. The last column indicates the number of problem-solving and decision making skill activities happened in every minute.

The selected learners and the educators were very keen and cooperative when performing the experiments. Learners performed both experiments in groups while the educators performed only the second experiment individually. Interestingly, learners, compared with educators, were more active and enthusiastic when performing experiments using the computer. Learners working in groups may be the reason. Both educators expressed during the interview, they would have done the experiment 2 better if they were in a group. "Learning in groups provides natural settings for sharing process, which are

important in developing a person's flexibility and ability to learn effectively " (Computers & Education; May 1998; page 73). Learning in small groups can improve achievements in mental functions (Sharan *et al.*, 1981) whatever socioeconomic level they come from (Shachar & Sharan, 1991).

Four types of 'cooperative interaction' have been identified and organized in the above problem solving activity. Video tape was played to observe these interactions in both experiments.

1. *One of the pair is working, the other is mostly observing*: both of them are working ~~together~~ but there is a gap between them in the level of contribution to the solution of the problem.
2. *Distributed work or parallel work on separate parts of the task*: both are dominant and want to contribute their part to the problem solution. They are aware of each other's will, and therefore they decide to divide the work between them. Sometimes distributed work is done for the purpose of completing the task in limited time.
3. *One of the pair is dominant*: one of the pair is dominant cognitively and other finds himself doing mostly routine work because of a wish to participate in the task actively.
4. *Both of them work together*: both of them are busy in the task while searching / receiving information each from the partner. If there are contradictions, they are solved by cognitive negotiation between them.

Second type of interaction was the highest in experiment 1 while the fourth type of interaction was dominant in all groups in experiment 2. Limited time to complete the task in experiment 1 forced the learners to distribute the work among themselves. In contrast, learners were found at a less pressurised pace when they were engaged in experiment 2.

Third type of interaction was also observed frequently in some groups in both experiments. Linguistic skills are contributing for this behaviour. The most able pair in communication found to be dominant.

Computer way of mixing the colours has given the better rate of problem solving activities. It is clear that computer operations are much faster than the manual operations so that the computers provide more opportunities to the learners in these activities.

Sub problem-solving activities in Experiment 1

Group	Problem identification	Further reformulation	Change in design	Change in technique	Change	Solution per minute	Frequency
1	7	1	1	0	0	0.18	
2	6	2	1	2	0	0.22	
3	8	1	0	3	0	0.24	
4	4	1	1	0	0	0.12	

Table - 5

Sub problem-solving activities in Experiment 2

Group	Problem identification	Further reformulation	Change in design	Change in technique	Solution per minute	Frequency
1	5	4	2	2	4	0.57
2	5	5	3	2	5	0.67
3	4	4	4	0	4	0.53
4	5	4	3	1	4	0.57

Table - 6

At least there were eight possible sub problem-solving activities in Experiment 1 and six in the Experiment 2. The above tables show the experiment 1 has given more opportunities to the learners to be engaged in the sub problem-solving activities. But learners were less concerned about these problems and did not take these problems further up to find the solutions. Manual way of mixing the colours creates number of other sub problems and it makes the learners to interact with other materials. Learners indicated in the interviews, that manual way of mixing the colours is problematic and time consuming, it clearly shows that they identified the problems.

Observers mentioned, in the interview, that the computer way of mixing the colours did not provide as many chances of identifying sub-problem solving activities as the traditional method. Video replay shows that traditional method makes the learners to deal with many equipments and materials. The use of many equipments and materials lead the learners into many sub-problem facing situations. When the learners perform the same experiment on computers, these chances are very limited, because they work in an ideal situation. Traditional way of conducting experiments are excellent in providing sub problem-solving activities to the learners. But in contrast, the traditional way experiments are weak in facilitating the learners to arrive at solutions if there are many sub-problem solving situations. Computer way of learning, facilitates the learners to continue further with their identified sub-problems to arrive at solutions. This view was also supported by the observers during the interview.

Male and female learners were compared by using group 1 (all females) and group 3 (all males) in the level of problem solving skill acquisition. Video tape was played for this purpose and their activities were observed. Both were found in equal level. This tendency is not supported in the literature." A significant number of females were more apprehensive about using the computer compared to males. Reinen and Plomp assert that women rate themselves lower on computer knowledge than men" (Computers & Education; Feb. 1996; page 26).

In problem solving, in the traditional method, the learners needed greater assistance from the educators than in the computer method. The reason being in the computer method only a few problem solving situations arose and the learners' eagerness in handling the computer, and ease with which trial-and-error method can be used in computer enable them to find the solutions to these problems by themselves.

Investigating skill

Observers had difficulties in identifying the investigating activities. Since they had little experience in identifying the skills, much time consumed in analysis before reaching a common decision. For instance, in Experiment 1 the followings are considered as investigating activities.

1. What is colour?
2. What makes an object to be in that colour?
3. Investigating the relationship between the size of the discs and the observed resultant colour.
4. What factors are involved in the drying process of the water paint?
5. What makes the discs to vibrate?
6. Why the discs sometimes do not rotate while the motor rotates
7. Investigating the relationship between the speed of the motor and the resultant colour observed.

Attempts to the above and other possible activities are counted from the video replay in each group per experiment. Observers and the researcher were watching together the video replay and discussed the activities. When all of them agreed upon, a particular activity was considered to be classified as an investigating activity.

The following chart shows the number of investigating activities in Experiment 1 and 2.

Group	No. of investigations in Experiment 1 (50 min)	Frequency per minute	No. of investigations in Experiment 2 (30 min)	Frequency per minute.
1	8	0.16	11	0.37
2	7	0.14	12	0.40
3	11	0.22	15	0.50
4	7	0.14	13	0.43

Table - 7

Once again the experiment 1 has given lot of chances to the learners to develop their investigating skill. In reality experiment 2 made the learners to be involved in investigating activities much more times than experiment 1. During the interview with the educators, they expressed their opinion that computers provide solutions to the learners' investigations in a very short time. It automatically makes the learners to engage more in the investigating activities. Learners mentioned in their response to the questionnaire that the interesting feature in the computer way of mixing the colours is the 'instant answer' to their investigations. They were of the opinion, that computer provides simple and shorter procedure for performing experiments. Learners responses reflect that traditional way of conducting experiments are not welcomed by them. Further, most of them stated if they have a chance to perform all the experiments on the computer, they would prefer to avoid the traditional way.

Male and female learners were compared, by using group 1 (all females) and group 3(all males, in the level of investigating skill acquisition. Video tape was played for this purpose and the activities of these groups were observed. Both were found in equal level like the problem-solving skill acquisition in both experiments.

Surprisingly the groups with weaker(in terms of their classroom and examination performance) learners performed well in the computer method experiment. Educators confirmed this findings in the interview. Similar research was carried out in the University of Western cape. The report sys, "University of the Western Cape students typically come from varied academic and socioeconomic backgrounds. Many of the students are from educationally disadvantaged communities and nearly all of these are first generation university students. In general these students will have had little exposure to technology..... Initially it was assumed that students with mathematical ability and those who had no fear for technology would be successful candidates in the Electronic Data Processing course. Contrary to our expectations no correlation was found between the results of the statistics course and the more practical Electronic Data Processing course. Students with a fear for technology achieved higher marks(Computers & Education: Computer literacy in the third world; Feb. 1996; page 23-29).

Communicating skill

Science involves highly complex and abstract subject matter that elementary and some high school students fail to grasp without concrete objects and opportunities for manipulations. (Science Instruction in the Middle and Secondary Schools: T. Collette, L. Chiappetta : Page 121,1986). The purpose of the group work is to create an environment where the involved learners can communicate freely. Through communication even highly complex subject matters can be understood easily by the participating learners in a group. Communication is needed in all activities in all stages for proper learning of the concepts.

Number of communications involved in learning the concepts were counted in the both experiments. Explanations, instructions, discussions and consultations by verbal or sign language between the learners or between the learner and the educator are considered as communication activities. Recorded video was played during this process, observers and the researcher combined together in formulating the communication activities.

Frequency analysis of learners communication activities in both experiments.

Group	No of communications in experiment 1 (50 minutes)	Frequency per minute	No of communications in experiment 2 (30 minutes)	Frequency per minute
1	21	0.42	41	1.37
2	25	0.50	46	1.53
3	24	0.48	44	1.47
4	18	0.36	39	1.30

Table - 8

The above table(Table -8) shows more communication activities were involved in the computer way

of mixing the colours. These communications are further classified into four categories based on a classification by M. Wild(1996)

1. *Off-task* : Communications are not related to the task.
2. *Isolated*: One or more communications occur without reference to the previous communication. Very often, talk at this level does not lead to meaningful developments in performance of the task. Performing the experiment at this level may also be accompanied by periods of silence and individual activity. (i.e. each learner acting in isolation)
3. *Coordinated*: Communications are relative and contextual, with one learner extending or even repeating a prior communication, or perhaps disagreeing with the previous communication and advancing a different perspective. Such disputes do not serve to develop task performance.
4. *Connected*: Communications often take the form of hypothesis, a new idea or an observation which is proposed, explained, elaborated, defined, questioned and/ or justified by two learners in conversation.

Observers viewed that the computer way of mixing the colours is rich in category 3 and 4 while the traditional way experiment contains mostly the category 1 and 2. Communications from the groups containing at least one female learner mostly fell into category 1 or 2, hardly ever in category 4. In the interview the female learners indicated that they were shy to communicate, because the procedure was filmed.

"Communication may be a function of a complex range and combination of variables, including:

- * type of software used;
- * amount and type of teacher intervention;
- * number and type of tasks undertaken by the children;
- * accessibility of hardware;
- * approaches to learning exhibited by the children(Biggs & Moore, 1993)
- * level of learner control; and
- * composition of groups(particularly with reference to gender)"

(Wild, M.,(1996)Investigating verbal interactions when primary children use computers: *Journal of Computer assisted Learning* : Volume **12**; page 71)

The impact of the above variables in the development of the communication skill is discussed below. Soft wares can be classified into two types in terms of the learner control. They are, (i) closed software(i.e. software that provided low learner control) (ii) open software(i.e. software that provided high learner control). The second type could be associated with ' more productive interactional styles' and the first type with only limited interactions(Anderson et al., 1993, p 247). The software used by the learners for colour mixing mostly aligns with the second-type. The learner on control of this software, has the chance of selecting the prime colours more than 16 million times(three prime colours, each having a scale of 0-256) in different proportions. Conversely, prime colour components of a given colour could be resolved in more than 16 million ways. Obviously, the type of the software used, played a major role in the communication skill development. This view is strongly supported by the observers during the interview.

In experiment 1, teacher intervention was in the form of assistance to the learners. Number of times learners were assisted to help them to proceed with their experiment. Most of the time, the educators were instructing, explaining and talking to the learners. The learners were, by themselves, not sharing their ideas, not helping each other and not expressing their potentials in a supportive learning

environment. In contrast, the teacher intervention in the second experiment was in the form of inducement. During the procedure, the learners were given extra tasks of more difficult nature to induce them to increase their communication level. Observers noticed that the learners became more active in the learning process which lead to more effective communication in sharing of ideas and helping each other. In a similar situation, learners completed their tasks without any outside help, gained highest scores(5 or 6 in a scale of 0-6), with 50% teacher help gained medium scores(3 or 4) and with over 50% teacher help gained lower scores(1 or 2) for skill developments(Journal of Computer Assisted Learning; May 1998; volume 15; page 78). My research findings and the above literature show that, constructive teacher intervention in the form of inducement is necessary to achieve higher level of skill developments.

I planned to have the same amount and same type of tasks in both experiments. The main difference between these experiments is the approach. In the process, the learners in all groups when performing the second experiment increased the amount of tasks and engaged themselves in more difficult tasks with greater curiosity and increased communicating skills.

Computer hard ware used in this research were the key-board and the mouse. There were many operations in the computer that could have been executed either by using the mouse or by using the key board. Learners showed confident in handling the mouse for various operations while the key-board for the same operations was rarely used to execute these operations. As the computer could be operated by only one learner at a time, the two learners had to take turns to operate the computer, but they had to communicate to complete the task. This arrangement provided a better chance of learning through communication and enhanced the development of communication skill. Educators performed this experiment individually, without any communication.

The following table-9 describes the composition of the learners in each group.

	Group 1	Group 2	Group 3	Group 4
No. of Male learners	0	1	2	1
No. of Female learners	2	1	0	1
*No. of very good learners	1	1	1	1
*No. of average learners	0	1	0	1
*No. of weak learners	1	0	1	0
No. of learners with linguistic skills	1	1	1	1

Table - 9

*Learners were classified as good learners, average learners and weak learners on their class and examination performance in physical science.

The recorded video tape was played several times and each and every time events were coded. The reliability of coding the videotaped communications on the observation sheets was tested by my

colleagues in the M. Ed course who are familiar with communication skills.

Excellent communications were observed in group 2 and 3 in both experiments. Observers viewed that the group 2 composed of mixed gender pairing learned and developed their skills through communications, because of the good male learner's contribution in communication. In general, good communication skills were observed when a good male performer combined with either male or female. Female learners in all groups were found to be less cooperative on levels of communications. It appears in the case of females, a good performer is not necessarily a good communicator (group 1 and group 4). On the contrary a weak performer appears to communicate better when combined with a good male performer. In the interview the female learners mentioned that they were shy in front of the camera. Weaker-male learner expressed his eagerness in the task and communicated well with his pair in group 3. Learners with language fluency cooperated well with their pairs and helped them to develop their verbal interactions.

Communication levels of mixed gender pairs were analysed with reference to group 2 and group 4. Mixed gender pairing communicates better when the male performer is good. The cooperation in communication depends on both gender and their performance level. My findings do not seem to appear with that of Underwood & Jandal, (1994) according to whom "Underwood and colleagues demonstrated the influence of group composition and in particular, the effects of mixed gender pairing on levels of cooperative interactions, finding that mixed pairs tended not to cooperate" (Underwood & Jandal, 1994).

In conclusion, the type of software, teacher intervention, composition of the group, amount of task and the type of tasks have an effect on the learners' communication. Another study supports this view by stating "that group composition, particularly with reference to gender, teacher intervention and software style were all likely to have an impact upon children's interactions" (Cummings, 1985). (Journal of Computer Assisted Learning; 1996; volume 12, page 72)

Attitude towards the experiments

Assessing the attitude is the most difficult task in these type of experiments. When a new way of teaching is introduced, due to the curiosity learners immediately jump to welcome the "new comer". Is this attitude long lasting? Questionnaires and interviews helped me to point the gauge on assessing the attitude.

As in the formative evaluation, the questionnaires (Appendix 3,4,5) were paper-based to elicit maximum feedback, in particular from those not accustomed to using computers. Post-task questionnaires were given to learners, and separate questionnaires were given to the educators. The questionnaires given to the learners were revised, and similar questionnaires were developed to cover the view of the educators in the experiments.

Eight learners and two educators were asked to answer the following questions in a five-point scale to allow greater focus on computer-based instruction.

Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

A. If given the opportunity to use the computer in practical work I am afraid that I might damage in some way.

1 2 3 4 5

B. Computers help me to organise my practical work better.

1 2 3 4 5

C. I could probably do most of the experiments by using the computer.

1 2 3 4 5

D. I hesitate to use a computer in the practical work in case I look stupid

1 2 3 4 5

E. Computers can increase the presentation of my practical work to a degree which justifies the extra effort

1 2 3 4 5

F. I am not in complete control of my practical work when I use a Computer.

1 2 3 4 5

G. Computers can allow me to do more interesting and imaginative work.

1 2 3 4 5

H. Computers make me feel uncomfortable

1 2 3 4 5

I. Computers make it possible to work more productively

1 2 3 4 5

J. I need an experienced person near by when I perform an experiment with the use of a computer

1 2 3 4 5

K. I really enjoy the practicals when I am told to use the computer.

1 2 3 4 5

L. Computers can allow self discovery learning in practical work.

1 2 3 4 5

Analysis of answers from the above questionnaire.

Question	Score from 8 learners	Average	Score from 2 educators	Average	Overall average
A	11	1.40	3	1.5	1.4
B	38	4.75	6	3	4.4
C	33	4.13	4	2	3.7
D	10	1.25	4	2	1.4
E	35	4.38	6	3	4.1
F	9	1.13	5	2.5	1.4
G	39	4.88	6	3	4.5
H	12	1.50	7	3.5	1.9
I	37	4.63	4	2	4.1
J	22	2.75	6	3	2.8
K	39	4.88	6	3	4.5
L	37	4.63	8	4	4.5

Table - 10

Most of the learners and educators strongly indicated that they are not afraid to use the computer in their practical work. Learners and educators mentioned that a week of training in computers changed them to be aware and unafraid of how computers work. If the computers are introduced in the science curriculum there is no doubt, the *social rationale*, argued earlier will be achieved. Learners strongly agreed the computer helped them in organising the practical work, presenting the practical work and to perform more interesting and imaginary work. They also mentioned the computer allows them the self discovery learning and they do not need an experienced teacher nearby. Learners indicated that they want to do more experiments with the computer and they are confident in handling the computer.

Another study conducted at the University of the Western Cape shows almost the same pattern like the above findings in an attitude survey. " Majority of the learners found working with computers enjoyable and stimulating. For example, 74% agreed that they could learn a computer language, 69% felt at ease in a computer class, 66% felt comfortable working with a computer, 51% agreed that they could get good grades in a computer course, 80% thought it is important to do well in a computer class and 72.8% said that computers do not scare them. Frequencies of the pre-questionnaire indicate that 76% of students felt positive about computers and computer applications. Only a few students had reservations about technology before they did the literacy course. For example 17% of students felt threatened by computers, 21% agreed that computers made them feel uncomfortable, 21% felt they could not handle a computer course, 20% agreed that computers rob people of their individuality, 18% felt that computers are used to manipulate people, 185 considered learning about computers a waste of time and 26% felt aggressive and hostile towards computers" (Computers & Education; Computer literacy in the third world; Feb. 1996; page 25).

Educators views were different from learners, they argued even the traditional way of conducting the experiment gives the equal chances like computer in organising the practical work, presenting the practical work and to perform more creative work. Educators were supporting the learners, in the view of the computer allows the users the self discovery learning. They mentioned, though the learners get the solutions in good time when the experiments are carried out with the computers, experiments are incomplete in the sense that they only used the visual -sense. They viewed that the computers are really helpful to the learners when the experiments are impossible to do in the laboratories because of the resources, time etc. Educators pointed that the learners do not need an experienced teacher nearby, when they are performing the experiment with the computer is suitable only for experiment 2 type situations which do not involve many variables.

By performing the experiment with the computer, the learners are able to experience each stage and each movement of the experiment. They are also directly involved since they can witness all the chances which occur. By using the computer, the pupils conduct and observe the experiment under ideal conditions which are not possible by traditional experiments.

"the Computer-based Instruction (CBI) programme exerted a more positive influence on the students' verbal and nonverbal interactions in the physics lessons on measurement than was the traditional method of teaching used in the study. Specifically, the qualitative excerpts showed that the CBI module was able to enhance the subjects' interpersonal skill viz.: support, collaboration, ease of interpersonal relationships, trust and rapport building more than the traditional teaching approach of talk and chalk." (Journal of the southern African association for research in mathematics and science education, Volume 1 - 1997; Joel Kiboss : Page 74)

Computer-based experiment was ' owned ' by the learners, even if the educator made some suggestions and raised tactful questions. It has given an opportunity to build on the learners' existing knowledge and also to glean information by personal research. Computer-based experiment, among other reasons, provided a successful and satisfying outcome for the learner to enjoy much.

5. Conclusion

Computer simulations allow the science educators to bring rich learning experiences into the classroom. The simulations often permit the learner to manipulate variables or parameters and then to observe the consequences of their choices. "Computer simulations can bring into the classroom aspects of the world or universe that are too expensive, dangerous, difficult, or too slow or too fast in occurrence to be experienced firsthand." (Tamir, 1986/86)

Computer-based experiments offer science educators a powerful technology to enhance laboratory work, often more exciting and meaningful to learners. Computer cannot replace the educator completely, but it can be used as an effective tool or as a facilitator in the process of learning. Learners can explore science phenomena in more accurate and precise ways than are possible by traditional experiments - at least for certain experiences. The computer simulation as a laboratory tool, provides higher rate of skill developments to the learners and to focus on data almost immediately.

Exposing a learner to the use of a computer assists in the following aspects:

a) to master the computer commands and procedures b) to make problem solving an easier task leading to increased efficiency in problem solving c) to improve investigating skills, d) to enhance linguistic skills and planning strategy while working with a peer. In computer-based experiments software style, accessibility of hardware, level of learner control, teacher intervention, composition of the group, amount of task and the type of tasks have an impact on the learning process.

Recording the events on a video cassette is very useful in analysing the findings of the research more thoroughly. One problem in this respect is that it may not reflect a true picture of the events as some learners, who could be camera-shy, may not behave naturally.

On the top of all, computer-based experiments can change the present learners' attitude in a constructive way, which is highly needed to the effective science teaching today.

6. What I have learnt?

When I joined to do the M. Ed in Science Education, one of my expectations was providing quality science education to the disadvantaged learners through my research. Over the two years the standard of science education has been deteriorating in South Africa, in particularly in the Eastern Cape province, making my hopes to fade. Surprisingly, my learners, with whom I have been engaged for my research showing great interest in science. Perhaps change in my approach had an influence on them. I feel that at least one educator is highly motivated and encouraged to continue his work. It is really an enlightens to the deprived community.

Proper planning is essential prior to the process is the big lesson I learnt over my project. I have been assessing myself with the same gauge, used to measure the learners' development. I am certain that my learners are going to benefit from my developed skills such as problem-solving, investigation and communication.

The research was much interesting for me from the beginning to the end. I had good cooperation from the learners as well as from the co-educators. Research taught me to be patient in difficult times and to honour others' feelings and values. I did not face serious problems except the research consumed much of my time than I expected.

The findings from this research is considered as too luxurious and it is not going to be utilised in the near future is my great disappointment. In fact the Computer-based science instruction is cost effective, only needs initial capital and enthusiastic science educators.

My main weakness was considering my opinions as the only perfect ideas. I admit that my opinions, before corrections were superficial. The research made me to analyse others opinions too. In future, I will critically analyse the opinions from various sources before I come to any conclusion.

I was also weak in expressing the findings in English. My lack of proficiency in English may irritate or confuse the readers of this paper. Since English is my second language, I had been and still now, reading a lot of magazines, novels and periodicals to improve my language proficiency.

Though I read a lot of articles for my references, I did not pay attention to make note of the authors, publishers etc. I had to search the references again to look the above said details. In future, I will certainly write down the details of the articles, immediately the reference is over.

I was not perfect in formatting the references too. I have seen the format of other authors and corrected mine.

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Appendix - I

THE DRAFTED PLAN OF ACTION

Date	Time	Plan	Comment
10-04-98		Drafting the plan for the research	completed on 12.04.98
15-04-98		Meeting the learners/ selection	completed on 16-04-96
16-04-98		Meeting the educators	completed on 22-04-98
17-04-98		Computer Training	started on 17-04-98
20-04-98		Computer training 2 learners	Completed
21-04-98		Computer training 2 learners	Completed
22-04-98		Computer training 2 learners	Completed
23-04-98		Computer training 1 educator	Completed
24-04-98		Mixing the colours-water colours	2 learners completed
28-04-98		Mixing the colours-water colours	book reference
29-04-98		Mixing the colours-water colours	2 learners completed
30-04-98		Mixing the colours-water colours	4 learners completed
04-05-98		Mixing the colours - water colours	training 1 educator
05-05-98		Mixing the colours - computer method	2 learners completed
06-05-98		Mixing the colours - computer method	2 learners completed
07-05-98		Mixing the colours - computer method	2 learners completed
08-05-98		Mixing the colours - computer method	2 learners completed
11-05-98		Mixing the colours - computer method	1 educator completed
12-05-98		Questionnaire (Learners + educators)	Completed
13-05-98		Interview - 2 learners	completed

14-05-98	Interview 2 learners	completed
15-05-98	Interview- 1 educator	Analysis-questionnaire
18-05-98	Interview-1 educator	Analysis - interview
19-05-98	Analysis / report	-----
20-05-98	Analysis/ report	-----
21-05-98	Analysis/ report	Interview 1 educator comp.
22-05-98	Analysis/ report	Analysis - interview
25-05-98	Analysis/ report	Analysis - interview
26-05-98	Analysis/ report	Interview 1 educator comp.
27-05-98	Report writing	Analysis
28-05-98	Report writing	Report
29-05-98	Report writing	Report

CONT.....

Appendix -ii

Observation Procedure

Group

Manual way of mixing the colour / Computer way of mixing the colours

	Frequency
1. Problem solving skill / Decision making skill
2. Investigating skill	
3. Communication /Response
4. Attitude towards experiment
5. Observation / Recording
6. Self discovery
7. Confident in handling the instruments
8. Enjoyment / play

Appendix -iii

SECTION A

QUESTIONNAIRE (LEARNERS)

1.What are the interesting features in the experiment of manual way of " Mixing the colours "

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2.What are the interesting features in the experiment of computer way of " Mixing the colours "

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3.How did the manual way of " Mixing the colours " help you in the learning process?

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4.How did the computer way of " Mixing the colours " help you in the

learning process?

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5.What do you like or do NOT like in the experiment of manual way of " Mixing the colours " and why?

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6.What do you like or do NOT like in the experiment of computer way of " Mixing the colours " and why?

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Appendix - iv

QUESTIONNAIRE (EDUCATORS)

1.What are the interesting features in the experiment of manual way of " Mixing the colours "

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2.What are the interesting features in the experiment of computer way of " Mixing the colours "

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3.How the manual way of " Mixing the colours " can help the learners in their learning process?

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4.How the computer way of " Mixing the colours " can help the learners in their learning process?

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5.Why do you like or do NOT like to accommodate the experiment of manual way of " Mixing the colours " in your teaching process?

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6.Why do you like or do NOT like to accommodate the experiment of computer way of " Mixing the colours " in your teaching process?

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Appendix - v

Section B

Please indicate whether you agree or disagree with each statement. This is a survey NOT a test, so there are no 'right' or 'wrong' answers just answer as honestly as you can. Please tick one answer for each statement.

Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

A. If given the opportunity to use the computer in practical work I am afraid that I might damage in some way.

1 2 3 4 5

B. Computers help me to organise my practical work better.

1 2 3 4 5

C. I could probably do most of the experiments by using the computer.

1 2 3 4 5

D. I hesitate to use a computer in the practical work in case I look stupid

1 2 3 4 5

E. Computers can increase the presentation of my practical work to a degree which justifies the extra effort

1 2 3 4 5

F. I am not in complete control of my practical work when I use a Computer.

1 2 3 4 5

G. Computers can allow me to do more interesting and imaginative work.

1 2 3 4 5

H. Computers make me feel uncomfortable

1 2 3 4 5

I. Computers make it possible to work more productively

1 2 3 4 5

J. I need an experienced person near by when I perform an experiment with the use of a computer

1 2 3 4 5

K. I really enjoy the practicals when I am told to use the computer.

1 2 3 4 5

L. Computers can allow self discovery learning in practical work.

1 2 3 4 5

RHODES UNIVERSITY

M. Ed. IN SCIENCE EDUCATION

1998

RESEARCH REPORT - 2

***"CAREER ORIENTED SCIENCE EDUCATION FOR
THE NEXT MILLENNIUM"***

K. NADARAJAH

Contents

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Abstract.

Learners must be enabled to develop the necessary life competencies to deal with new demands and challenges of the fast developments of science around the world. Without a serious commitment to a sound foundation of science and technology, the dreams of a bigger and better future for millions of our nation will be in vain and the vision of an African Renaissance will never become a reality.

This paper considers different aspects of career oriented science education and examines its various curriculum locations. It concludes by raising some issues concerning the need for skill acquisition and awareness of the world of work for a South African learner to meet the challenges of the next millennium.

1. Background

We live in a world of change, more rapid than ever before. Two hundred years ago it took some months to sail from Europe to South Africa. Now, the aeroplanes cover the same distance in less than eleven hours. A letter which in earlier times took two months to arrive from India, can now arrive almost instantaneously through e-mail. We can watch the President of America or a live cricket match in Australia on television via a satellite and we can see and talk to our friends any where in the world through Internet. Distance has shrunk because of our transport and communications systems. The new world is now so “small” that not a single country can afford to go its own way without considering the complex interrelations between the countries. We must all change to fit in with everybody else.

World of Work

Things will never be the same again. A tidal wave of change is sweeping over the entire world. Those who are reactionary, and not prepared for change, will be swept off their feet. Do we live in a country of change? Yes- in many respects but not in preparing the learners towards careers needed to accommodate the changes that are taking place. South Africa is still preparing its school-leavers for a world which disappeared years ago, and many educators use methods which are many years behind the times. My literature review supports the above view. Christie, P., and Collins, C., (Bantu Education: Apartheid Ideology and Labour reproduction, 1990) indicate that the science education in South Africa is old, rigid and mend to cater for only a handful of people. Further, these ill prepared school leavers making the unemployment to rise every year. A higher standard of living for South Africans is dependent on employment creation. Clearly the government does not see itself as the provider of employment; the civil service is being downsized and there are firm commitments to privatise state assets(Professional Management Review, October 1996). On the other hand, as the population grows, the amount of school leavers also grows. Very rarely new jobs are being created resulting in the high rate of unemployment among school leavers.

Only a handful of learners can benefit from this system. As it is indicated in the literature review, less than 2.5% of the total learners would get the tertiary education and the rest drops out along the schooling period. The present system is not designed to cater for the majority of the

learners.

The need for the change in "career world" is clearly illustrated above for the benefit of all South Africans. Further, the National Curriculum Framework(NCF) document, which is informed by principles derived from the white paper on Education and Training(1995), emphasises the need for major changes in education and training in South Africa in order to normalise and transform teaching and learning. Emphasis is placed on the necessity for a shift from the traditional aims-and-objectives approach to outcomes-based education. This paradigm shift, known as Curriculum 2005, is a necessary prerequisite for the achievement of the following vision for South Africa:

"A prosperous, truly united, democratic and internationally competitive country with literate, creative and critical citizens leading productive, self-fulfilled lives in a country free of violence, discrimination and prejudice"(Curriculum 2005 document: 1997)

My study considers, in the context of science education, the current trend in careers, the skills needed and the awareness of the world of work to produce, well- equipped school leavers to the world of work.

Current Trend

One hundred years ago 80% of our population lived off the land but now only 6% are farmers or farm-workers.(Population census : 1996) More food is produced, with less people working for it, leaving the farm-machines and fertilisers do the spade work. Nowadays computers are taking over the jobs in the offices. There are only a few bank-tellers, because auto-tellers in the street, tele-banking and Internet-banking are performing the bank-tellers job. Fifty years ago 80% of the workers in factories, were on the floor, but today only 20% remain because automatic robots and mechanical hands- do the work.(Central Statistical Service: 1995) As we look towards the next century with unprecedented work patterns, it is imperative that career oriented education becomes more central part of a curriculum. It is also imperative that this career oriented education remains an integral part of professional development and training(Harris. A,:1998).

The information age and the pace of scientific and technological advance, may provide numerous career opportunities for the learners. In my view, my study is appropriate at this

juncture, to explore the career opportunities in relation to science education.

Skills

New kind of personal competence is required to cope with a new kind of situation. It may be hard to accept that an education in knowledge is not enough. An educated person was previously considered to be a person who knew a lot of facts and had passed a lot of examinations. This kind of education makes a person to live in the past, but not in the present. Majority of the present school-leavers cannot obtain careers which require certain skills or experience. In fact the content based present educational system never concentrated on the learners' skill developments, yet skills are the centre piece for any career.

Burgess, T., (1986) indicates a serious imbalance in England, as we see it here in South Africa, between “education” and “training”. He states, that an educated person is often able to understand, but not to act. Indeed, young people are not taught to use knowledge in ways that are relevant to the world outside school. The basic skills such as the articulate use of words, competence in dealing with figures, measurements and quantities, the ability to remember instructions and facts, reasoning skills for problem-solving and decision making, and social skills are important to learners, so that they will not only survive, but also succeed. (Lifeskills Education Project, UCT: 1984)

The followings are two examples of advertisements for appointments that implies the importance of experience and skills in acquiring jobs in the field of science and technology. " Requirements for a Project planner/Estimator: Recognised engineering trade and/or Industrial Engineering / Production Management diploma + At least 5 years hands-on project management/planning experience + Sound interpersonal organisational and communicating skills + Self starter who can work independently..... , Requirements for a Manager: BSc Electrical Engineering degree or an equivalent qualification, coupled with 5 years or more experience with well-developed people skills with the ability to negotiate effectively and close deals are important attributes sought...".

(Sunday Times: Appointments: November 8 , 1998: Page 13)

Most of the employers require experience, since they believe the experience in a particular career provides a better chance for skill acquisition and developments.

Perhaps in the future, when the Curriculum 2005 is implemented in all grades, all the school leavers may possess certain skills which will help them to obtain employments.. Curriculum 2005 focuses on skills which are essential for the learners to lead a better life. The interesting part of the curriculum is that learners can obtain the same kind of skill from different learning areas. Classification / sorting is a skill, which can be acquired in any learning area or field. For instance, some learners classify the living things in Biology according to their properties, some learners classify the elements in Chemistry according to their properties and other learners in Mathematics sort the numbers according to their nature. In all these aspects learners are developing classification skills.

According to the report of the National Committee on Further Education(August 1997): there is a growing recognition world-wide that education and training are fundamental to economic and social development. In fact, education/training is fast becoming a strategic good, where a country's ability to compete effectively in the global economy is going to depend on skills of its people.

Awareness of the World of Work

Once the learners have left the school or tertiary educational institutes, they will spend most of their adult life " on the job". It is therefore important to find a career in which they will be happy for the rest of their life. To be able to do this, the learners need to know about themselves and to know different careers. Learners' abilities, interests and personalities play an important role in choosing the careers. It is always a good practice to make the learners aware about their potentials and the different careers for the benefit of our future work force. According to Harris. A(1997), in secondary schools a common model of career oriented teaching is through subject teaching. This occurs where the world of work is used as a context, or resource for subject teaching. Learning areas like Natural Science, Technology and Economic and

Management Sciences have obvious linkages with the world of work. Other learning areas use the world as a resource for subject teaching. In this respect, the learning is subject driven, it is learning through the world of work.

Career oriented education is neglected in the present South African curriculum. According to the report of the National Committee on Further Education, some 2.2 million learners are concentrated in the pre-employed category, absorbing 72 per cent of all FET expenditure. Almost all of these are found in academic senior secondary schools with only 58 664 in technical colleges. Unless viable alternative learning paths for skill development are developed and supported with additional public funds, more learners will be pushed into highly subsidised senior secondary schools, thus skewing FET provision for the pre-employed even more. (Department of Education, Pretoria, 1997).

To assess the current trend in careers and the skills needed for the science learners I visited some local industries and few tertiary institutions. I prepared two questionnaires with qualitative and quantitative questions, to be completed by selected public relations officers, focussing on science related careers and skills before this visit. The answers to these questionnaires and the interviews held thereafter helped me to formulate an idea about the current trend in careers and the skills needed for the science learners.

In order to assess the awareness of the world of work among the learners, I decided to include a survey on the career awareness measurements. For this purpose, I chose 20 learners from a disadvantaged school in King William's Town.

I also looked more than 300 careers, available to the current learners in South Africa. These careers were classified on the basis of learning areas, under a point system developed by me. Findings from this research illustrate that science education with appropriate skill developments has the potential to provide employments to many learners and that priority should be given to make the learners aware of the changes in the world of work.

2. Literature Review

The following literature review supports the change in the world of work. Further, it illustrates the present position of school leavers in South Africa. Since my study is focussing on the competencies needed to the South African learners in the world of work, I felt it is appropriate to mention here.

" The world, in which we live in, is characterised by vast technological changes. At the dawn of the 21st century we are experiencing a technological revolution. The new technology of today is tomorrow's old technology. People in the world of work continuously have to adapt to these changes. The Intra-Internet have had a radical impact on the working environment. People all over the world can communicate directly with one another via cyberspace world. The nature of work has also been influenced through this technological revolution and new careers are emerging every day. It is also becoming common knowledge that people will have more than one career during their lifetime partly due to the ever-changing workplace. "

(MY CAREER-1998, Department of Labour, Page: 3)

More than 15 million adults in South Africa do not have a basic school education. Perhaps as many as 10 million adults cannot read and write at all. The majority of people have come out of 'Bantu Education'. That system, linked by the structure and ideology of apartheid, was so poor that it denied professional development and training for the majority. (NEPI Reports on the National Education policy Investigations; 1992). South Africa is ranked 90th out of 175 countries on 1997's Human Development Index which provides a country-by-country measure of achievements in terms of educational attainment, professional development and adjusted real income. According to the 1996 index, South Africa ranked 100th which was the average between South Africa's white population(ranked 24th overall) and the black population (ranked

124). The position was similar during 1997, with the white population falling into the high human development category and blacks into the lower end of the medium human development scale(Human Development Index: 1997). The present lower human development, plays a major role together with population explosion and scarcity of resources in creating the unemployment crisis in the labour market. To break the current constrains, a growth rate of 6 per cent in the economy and job creation of 400 000 per annum by the year 2000 are needed(Professional Management Review, October 1996).

"The National Teacher Education Audit (1995), commissioned by the Ministry of Education, concluded that teacher training in South Africa was so poor that the entire system needed to be rebuilt. The report indicated that training at about 90% of the country's 109 colleges of education failed to prepare student teachers for the challenges of the new South Africa and the 21st century". It continues that "the poor facilities and lack of adequately trained mathematics and science teachers at most traditionally African schools present considerable problems for the future improvement of mathematics and science education, particularly considering that the number of Grade 12 candidates is expected to almost double in the next 10 years."

(SA SCIENCE AND TECHNOLOGY INDICATORS -1996 ; page 19)

The following tables give an idea about the school leavers.

Headcount of Grade 1-12 pupils in 1993 and 1994

Grade	No. in 1993	No. in 1994
1	1558864	1583411
2	1229822	1224394
3	1153196	1174371
4	1039563	1071948
5	1023749	1041671
6	906490	934862
7	827811	859862
8	871204	917969

9	756164	801065
10	637291	662990
11	553730	588899
12	505045	546156
Total	11062929	11407598

Table - 1

More than 60% of the enrolled learners in grade 1 do not reach grade 12. Either they repeat or leave the school without gaining any certificates.

Grade 12 examination results (1990 - 1994)

Year	Pass in % (with exemption)	Pass in % (school-leaving certificate)
1990	16.7	36.3
1991	17.9	36.3
1992	16.9	39.0
1993	14.6	36.7
1994	17.9	40.1

Table - 2

All the universities require Matriculation exemption for enrolment. From the above table less than 20% of the grade 12 learners can get the university admission. Technikons too require very good matric results for admissions.

(SA Science and Technology Indicators: 1996: p 178)

University degrees awarded by broad field (1990 - 1993)

	1990	1991	1992	1993
Natural sciences and engineering	6749	7077	7188	7449
Health sciences	3412	3434	3643	3560
Social sciences and humanities	26077	30297	31197	33215
Total degrees awarded	36237	40808	42028	44224

Table 3.1

(SA Science and Technology Indicators: 1996: p 229)

Technikon diplomas awarded by broad field (1990 - 1993)

	1990	1991	1992	1993
Natural sciences and engineering	3223	3411	4158	4331
Health sciences	605	704	729	803
Social sciences and humanities	4657	5173	5876	6221
Total diplomas awarded	8484	9288	10763	11355

Table 3.2

(SA Science and Technology Indicators: 1996: p 263)

One of the legacies of our past educational policies is the imbalance between the number of students proceeding after their high school education to a degree in arts and those choosing a scientific or technological career. While most institutions which historically catered for whites and offer relatively good science and mathematics education up to Grade 12, those which historically catered for the majority of African pupils have much less to offer. Pupils from these institutions generally leave school without adequate training in mathematics and science, engineering or technology. The reality is that for the foreseeable future, the majority of African pupils will continue to attend these institutions which are mainly situated in the rural areas and townships. Clearly, facilities and the methodology in these institutions need to be improved to allow them to prepare greater number of African learners for careers in science, engineering and technology.

"Of all the people in South Africa with university degrees the single greatest proportion, 26% are general arts degrees. This skewed state of affairs is even more dramatic amongst the black and particularly the African population (and within this section women were the worst represented). Of all degrees held by Africans, 42% were general arts degrees..... South Africa is simply producing far too few scientists and engineers in relation to other disciplines, concluded Prof. Ramphela, Vice-Chancellor of the University of Cape Town, voicing the concern of those involved in shaping a new educational future for South Africa "

(The Year of Science and Technology: Calender 1998, Page : 6)

In 1994, there were about 11.8 million school pupils attending the 22493 schools in South

Africa. (Department of Education, South Africa 1995). In the same year, school pupils constituted 29% of South Africa's total population of 40.4 million (Central Statistical Service, South Africa: 1995). In 1995/96, the national budget allocation to pre-primary, primary and secondary education was R 28.5 billion, which represented 87.5 % of the total education budget. This R 28.5 billion represented 18.5% of total government expenditure, and 5.7% of GDP in 1995(South Africa Yearbook, 1995)

The huge investment of R 28,5 billion in education produced a few thousands graduates of which less than 2.5% science oriented graduates leaving majority of the learners unemployed or as unskilled labourers. Under the Curriculum 2005, Further Education and Training(FET) phase is made up of Grades 10 to 12, has very important role to play in bringing about the necessary human resource development for economic transformation. There are three target groups who require FET: the pre-employed, employed and unemployed. The current FET arrangements are skewing provisions towards the education of the pre-employed. There is comparatively little training for the employed and even less for the unemployed(National Committee on Further Education: Department of Education, Pretoria, August 1997)

3. Methodology

My plan of action has two sections. Visiting local industries is the first part and the other part is visiting tertiary institutions.

Initially I planned to visit some local industries to find detailed answers to the following questions.

1. What are the careers available in each of the industries?
2. What are the requirements, in terms of knowledge and skills to the above careers?
3. What proportion of the above careers are science oriented?
4. Which sectors of the science are required to obtain the above careers?
5. How often they recruit for the above careers?

I wanted to get the answers for the above questions through interviews. Question 1 can provide an idea about the jobs, from the casual labourers to the top management available in each industries. Question 2 measures the level of education such as tertiary, secondary etc., and the experience needed to such employments. Quantitative question 3 can provide the significance of the science education. Question 4 and 5 are the important to restructure the present curriculum. The industries I selected for my research are Da Gama Textiles, King Tanning Company, Mercedes Benz of South Africa and Bokomo Feeds. These industries are within a radius of 50 km from my place. I did not want to spend much on transport. I am aware that these industries do not cater for a wide variety of careers but I think they are good samples for my research.

Next part of my plan is contacting educational institutions. Technikons, technical schools and universities are the main feeders to the job market. My questions to the educational institutions are similar to those for industries. I hope, the educational institutions design the courses in a such a way as to meet the demands in the labour market. The following questions are formulated for educational institutions.

1. What are the courses available at your institution?
2. What are the courses available for the science oriented secondary school learners?
3. Are these courses designed in relation with careers?
4. What sectors of science are needed for the learners to enroll for the courses?
5. What skills are you looking at for learner enrollments?
6. What skills are you developing?

(Please see the Appendix 1)

I hope, that the above questions and interviews which are aimed at the following institutions will provide the information of the courses offered, entrance requirements, learners' developments and the difference between Technikons and the technical colleges.

1. Border Technikon
2. King William's Town Technical College
3. Eastern Cape Technikon
4. East London College for Arts, Business & Technology.

DRAFTED PLAN TO ANALYSE THE INFORMATION

The main aim of my research is exploring the current trend in careers and predicting the possible career opportunities, for the future science learners. For this purpose, I want to begin with surveying, the careers available at present in South Africa, for the science oriented learners. There after, I want to analyse the learning areas and the skills suitable for these careers. At last, I am going to analyse the specified science fields needed at present as well as

in the future for the above learning areas.

The data, which I gather from the industries may provide necessary information of the current careers and the skills needed to these careers. The information obtained from the tertiary institutions are going to be used to formulate the learning areas for each career.

I also want to include the information from the software called "Expo-98" career guidance. On my request, Green Bean Production- a career guiding services company, sent this programme to me on a disc. I downloaded this programme in my computer. "Expo-98" career guidance which elaborates about the courses and their availability in the tertiary institutions in South Africa. If learners have the access to this software, that can easily choose the relevant subjects in the secondary school which will enable them to become professionals in a particular career. I regard this software an important resource for my research.

Analysing the information is a very difficult task and time-consuming process. I decided to allocate six weeks for this analysis. There are many implications and difficulties in this research. The research will be carried-out only in a small scale in the central region of the Eastern Cape. The institutions in this region do not offer wide variety of tertiary courses to the learners. There is no guarantee that the learners in this province will continue their studies in the institutions located in this province. On completion the learners can get employment in other provinces too.

Prior to the proposed interviews I did contact the industries as well as the educational institutes and explained my proposal. I requested them to provide relevant people who can be interviewed, at their convenient time, for my research. Most of them did not reply immediately. I faced difficulties in persuading them to be interviewed. Some agreed but they were very reluctant to disclose the information about their industries or institutions. I realised that they were suspicious that, in the name of research I would misuse the information. Somehow I convinced them to face the friendly interviews and promised them that I would not disclose their names or positions. Most of them did not turn up for the interviews as scheduled, instead they postponed with excuses. I was looking forward, extracting something from them. I kept

on trying and finally I managed to interview them telephonically. Their responses were written by me and then coded and classified. I phoned them again, for clarity on some points which were not clear to me. The modified findings from the interviews are discussed under the Results.

I also want to look how well we can equip the learners with creative skills, to initiate, to undertake and complete tasks competently, and the ability to cope with everyday life in cooperation with others. I hope to gather the data for this purpose from the answers to my questionnaire provided to the industries.

CAREER AWARENESS MEASUREMENTS

One thing I noticed is that the marketing people in the various institutions are not aware of the new curriculum. Further more they have less knowledge about science.

Fortunately, some of my friends working in the industries and the institutions helped me with information without any hesitations. One suggested that I contact the Department of Labour for my research. On my request the Department of Labour sent me their publication, a fully illustrated career guideline to the learners called " My Career - 1998 ". The 594 page book contains full range of career opportunities within South Africa.

During the interviews, I came to realise that most of the learners register for the courses in the tertiary institutions without being aware about the careers suitable for them. Even in the industries most of the employees never planned to choose the particular careers. It appears to me that learners in secondary schools are not informed about the careers appropriate for them. To verify the career-awareness among the learners I altered my plan. I conducted a survey on career awareness among the learners in my school.

This survey was carried out in the Forbes Grant High school a week before they sat for the end of the year examinations. Twenty learners were selected at random from grade 11 and 12. The school has five divisions in each grade 11 and 12. Two learners were selected from each division to make 20 learners of which 10 of them are girls. They were given the following questionnaire in the morning to answer. The whole morning session was given to them and

the answer scripts were collected in the afternoon.

(Please see the Appendix 2)

We are rapidly approaching the 21st century with very few days left to the next millennium. Are we ready to face the challenges of the next millennium?. The most worrying aspect with regard to the employment is the world-wide recession in economic activities. In South Africa the Gross National Product was adjusted downward over the last few terms: this being necessary at a time when the need for job-creation is high.

A table in appendix 4 shows the possible careers available at present in South Africa for the secondary school learners. The majority of these careers need further training in the tertiary institutions. The table also indicates the knowledge needed from the various learning areas .

(Please see the appendix 4)

Political, economical and technological circumstances are changing the careers every day. All the changes, with which we are bombarded continuously , create a lot of confusion and uncertainty within us. The careers listed above are the present profile and there is no guarantee they will exist in the next 20 to 30 years. It is obvious that the science and science related education controls the larger sector of the careers and also it is interesting to note that the natural science and technology are the big giants to create new careers and to destroy the existing careers.

I looked at more than 300 careers, which are available to the secondary school learners today. Some careers are closely related while at the same time others have branches or specialised fields. For example, the career of a medical doctor, needs preferably three learning areas, and has a variety of specialised fields. In the table, the career of a medical doctor has been classified as a single career to save time and resources.

Point system

After the careers have been listed, the learning area requirements for the careers are researched. The curriculum 2005 gives the guide lines to these learning areas, but at present the learning areas are being called "subjects". Most of the people whom I interviewed are not aware of the learning areas. Even the newly published career guide line book , My Career-1998, mentions the requirements in terms of subjects. I faced difficulties in allocating points to the learning areas.

The most needed learning area for a particular career was awarded 3 points, and the secondly important was awarded 2 and next needed learning area got 1 point. For each career, the first three learning areas are selected in the priority order . Interviews and the related books on career guidelines are used to categorise the learning areas.

4. Results

Findings from the interviews with Technikons and Technical colleges are briefly discussed below.

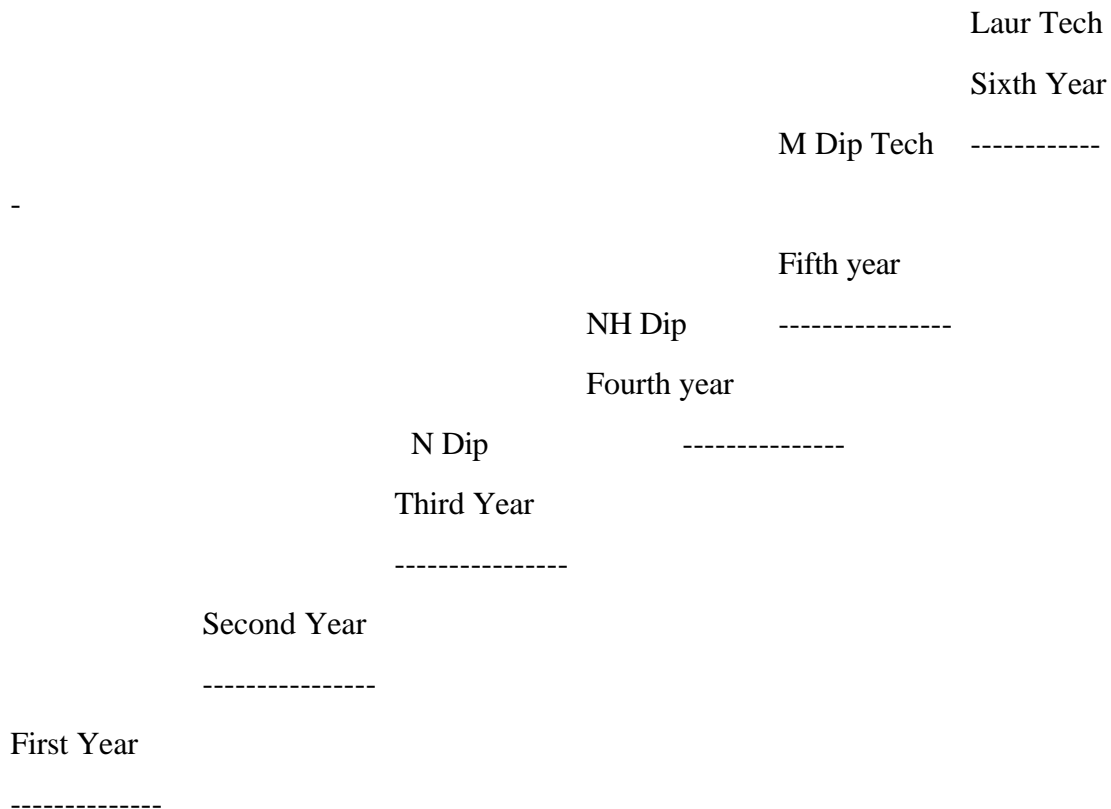
Technikons and industries function together to provide a unique type of education for the learners which can be called 'partnership education'. This cooperation allows industry to play a role in formal education, and then Technikons to develop a relationship with industry so that it designs and structures courses to meet the needs of the industry. The learner is the overall winner, in that the learner is offered a balanced education with proportionate amounts of theoretical and practical knowledge-a go ahead that provides a distinct advantage in the scramble for employment. This partnership between industry(the eventual employer), the Technikons and the learner, is what Technikons education is all about.

Techinikons provide education at a tertiary level. Such education is provided in accordance with the technological manpower needs of the country. Education from the technical colleges is lower than the tertiary level and it offers artisan training courses for the learners which are called ' the N stream'.

Technikons, like other tertiary institutions, strive for the promotion of knowledge and skill. However, the emphasis at Technikons is on the practical application of knowledge in the training of manpower. This is achieved through intensive cooperation between the Technikons, industry, commerce and the learner. Technical colleges help the learners to become trades

persons such as motor mechanics, fitter and turner, electrician, bricklayer etc. Learners, after serving a certain period of time as an apprentice (normally four years), would also be required to obtain an N₃ qualification. Meeting this requirement will allow one to write a trade test which will enable one to practise the trade chosen. In addition to the technical courses based on science, these technical colleges also offer certain courses in the humanities field as well as courses enabling students to study towards their matriculation Senior Certificates.

Technikons provide career-oriented education, in other words they educate people for a specific career or vocation. The training is both theoretical and practical, with learners alternating their studies at the Technikons with application of the knowledge and skills gained during their formal training in the practical work situation. Technikons are solely responsible for 'the T courses' which are tertiary at nature. The step diagram below shows the progress of a learner at the Technikons.



Step diagram

After three years of study at the Technikons learners qualify for a National Diploma (N Dip) in

their specialist field. Having obtained NDip enables one to study towards the National Higher Diploma(NH Dip). This qualification needs a minimum period of one year's study, which also consists of a combination of theoretical and practical training.

The NH Dip leads on to the Master's Diploma in Technology(M Dip Tech) which also requires a minimum period of one year's study. Finally, having obtained all the above three qualifications, a learner may study towards the Laureatus in Technology(Laur Tech) which is the highest qualification Technikons have to offer. The Laur Tech requires a minimum period of one year of study which consists of independent applied research.

Further more, Technikons offer short, intensive courses to accommodate the special needs of industry and commerce.

Traditionally, Technikons have had the image of catering only for courses in the engineering and science fields. Gradually, this image is changing. There is, in addition to the science and engineering fields, a whole spectrum of courses on offer in the following categories -a few examples of which are listed below.

Art and Design	Performing arts, music, clothing, graphic, interior, textile, jewellery.
Hotel and Catering	Chefs, reception, food service management, commercial catering, home economics, restaurant management, hotel management.
Commerce & Management	Internal auditing, company administration, accounting, marketing and sales management, accounting technicians, organization and work study, personnel management.
Computer:	Computer data processing, system analysing, computer programming

General Public relations, journalism, library and information science.

Secretarial Various secretarial courses, legal, medical, executive

In the view of the tertiary nature of Technikons prospective learners must possess a Senior Certificate, for admission to their courses. Further more, certain courses have additional admission requirements. Learners from the science streams have an advantage to be admitted in many courses which are not even classified as engineering or science.

Industries indicated the following skills are needed at work for various reasons.

Communicating Skills: Verbal skills, the articulate and fluent use of a large vocabulary, the ability to describe situations and events and the ability to give instructions and explanations are greatly needed in most of the careers.

Reasoning Skills: Many jobs are demanding the competence in applying principles and rules to problems and making decisions on great variety of questions and problems.

Social Skills: At present, world of work welcomes the ability and experience in dealing competently and in a pleasant, acceptable manner with all kind of people such as administrators, seniors, peers, juniors and anybody from a different culture.

Numerical Skills: Competence in dealing with figures, measurements and quantities and quotations are important in many employments.

Further, the world of work is expecting the employees to acquire the skill of remembering instructions and data, sizes, time-tables, business deals and past and future events, without reminder.

Career Awareness Measurements - Results

Forbes Grant High School, in King William's Town, where the career awareness research had taken place, has a well equipped career guidance teacher. All the classes have at least one guidance period per week though it is not an examinable subject. The school curriculum is considerably wide. The following subjects are catered for the learners.

1. Xhosa
2. English
3. Afrikaans
4. Biology
5. Physical science
6. Mathematics
7. History
8. Geography
9. Accounting
10. Economics
11. Business Economics
12. Typing
13. Home Economics
14. Art
15. Agricultural Science

Each learner should take six subjects. Xhosa and English are compulsory, other four subjects are optional for them.

The following table shows the number of learners enrolled per subject in grade 12.

Subject	No. of learners
Xhosa	223
English	223
Afrikaans	174
Biology	156
Physical Science	38
Mathematics	91
History	63
Geography	54
Accounting	36
Economics	61
Business Economics	36
Typing	19
Home Economics	26
Art	34
Agriculture	38

Biblical studies 66

Table 4

The pattern in grade 11 is similar to grade 12. Learners select the subjects at their own choice. The questionnaire is designed in such a way that it shows what motivated them to select the subjects. A sample of 20 learners forms less than 5% of the learners' population in grade 11 and 12.

The following table shows the subjects taken by the 20 learners.

Xhosa	20	English	20
Mathematics	06	Physical Science	04
Biology	11	Agriculture	04
History	06	Geography	07
Accounting	04	Economics	04
B. Economics	04	Art	03
Typing	03	Afrikaans	14
Biblical studies	08	Home economics	02

Table 5

Learners mentioned so many different careers as their top-ranked professions. Learners' career preferences were scaled in a 1 -10 point system. Each learner's best choice was awarded 10 points and least choice obtained 1 point. I arranged the first ten professions of the learners' choice in the descending points order.

(Please see appendix 3)

The following table illustrates the professions and the points.

Profession	Total Points	Standard Deviation
Doctor	191	0.69

Engineer	172	0.99
Accountant	135	2.28
Pilot	116	2.23
Computer expert	110	1.84
Technician	106	2.09
Nurse	087	1.29
Lawyer	066	2.09
Chemist	053	1.7
Security force	038	1.25

Table 6

There are many careers available in South Africa, but learners are not exposed to them. Smaller standard deviation indicates that the learners' view on profession is much closer.

The next table shows the learners' expectation on professions.

Profession	No. of learners wish to attain
Pilot	5
Engineer	4
Technician	3
Accountant	3
Computer expert	2
Lawyer	2
Doctor	1

Table 7

Even if the learners wish to obtain the above professions, their choice of subjects will restrict

them. The following table shows the number of subjects they study related to a certain career and the number of subjects essentially needed to that career.

It clearly shows that wrong subject choice is the limitation to achieve their desire.

The following table shows the relationship between the number of learners wishing to obtain a particular profession and the possible number of learners who can meet the requirements for their choice.

Profession	No. of learners wishing to obtain	Possible No. of learners with appropriate subjects	%
Pilot	5	2	40
Engineer	4	1	25
Technician	3	1	33
Accountant	3	1	33
Computer experts	2	1	50
Lawyer	2	2	100
Doctor	1	0	00
Total	20	8	40

Table 8

Most of the learners also indicated that their selection of subjects towards their career goals are not appropriate. They agreed that they were not aware of either the careers or the admission requirements for their proposed careers.

There are many factors contributing to their non-awareness of these careers. Firstly, they were not exposed to the careers. The media, such as T.V., Radio and news papers do not advocate the importance of career guidance to the learners. Most of the text books available at present

do not cover the different types of careers and their values. For example, an English text book does not present a story about a horticulturist nor does a science book have a picture of an architect or a navigator at work. Some professions such as doctor, lawyer, technician etc. are always covered in the media as well as in the text books.

Secondly, the learners themselves do not bother about their future career. Many learners do not realise their potentials and do not choose appropriate secondary school subjects. In most cases learners want to choose the subjects which are chosen by their peers or intimate friends.

Thirdly, the learners are not motivated by their parents, elderly persons and teachers to choose the appropriate subjects to obtain the careers. Many learners are not channelled towards their interests. Learners' skills are not considered or valued and their interests are always neglected.

The Natural Science learning area is compulsory for the majority of the careers. Out of 292 careers researched 192 careers could not be pursued without Natural Sciences.

No. of careers requiring Natural Science	Points
114	3
63	2
15	1

Table 9

The mean point 1.7 for the Natural Science learning area illustrates the significance of the science education. The smaller standard deviation value (0.6) points out that science education is needed for the most of the careers.

The above survey shows that the majority of learners should choose the Natural Science learning area to make their life brighter. " The largest vacancies existed in the field of health-science and technology, where there was a recorded shortage in 1992 of 9812 personnel(equivalent to a vacancy rate of 8,5%), probably due to increased emphasis on the availability of primary health care for the entire populace."

(SA Science and Technology Indicators - 1996: Page 89)

Vacancy rate in the science related sectors are three times higher than any other sectors. But the reality is that the majority of the learners in South Africa are not part of the Science education, which causes the unemployment rate to rise each and every year. South Africa's Green Paper On Science and Technology (Department of Arts, Culture, Science and Technology, 1996) confirms that human resources constitute the country's most basic assets and that a 'technologically fluent work force is a prerequisite for economic growth which underpins job creation and an improved quality of life'. South Africa has tended to focus on supply rather than demand measures in its human resource development thus far. Given the current level of competition in the labour market and the expense of human resource training, a pattern of human resource development which makes so little attempt to match the skills of the people whom it produces with needs of the market-place may appear increasingly wasteful.

FUTURE TREND

New initiatives imply a need for renewal. It requires forward thinking rather than backtracking. How the world of work is going to change? The answer is not such simple. The most complicated 'world of work' depends on the political, economical and technological factors. The above three factors are changing all over the world. The last one changes rapidly in the technologically advanced countries. South Africa should adjust to these changes for the benefit of its citizens.

Information Technology

Information Technology is the biggest giant that is going to consume majority of careers tomorrow. Technology has rooted in all sectors. It destroys present careers and produces new careers that we never thought about before. Does Information Technology need any contribution from the Science Education? Since science and technology are intertwined,

existence of Information Technology is not possible without science education. The skills and the knowledge of science helped the development of Information Technology in all the stages ranging from invention, implementation, maintenance and the developments. Science oriented careers needed for this IT are electronic engineering, electrical engineering, somatology, biomedical engineering, computer hard ware technology etc. They have a great opportunity for development. Learners should be guided to choose these streams as they are enhancing.

Environmental Studies

Our environment is suffering from all corners in an alarming rate due to the development of science. Scientists are becoming more and more aware of the damage that is being caused to the environment and the urgent need for remedial measures. As a result of these, studies in the field of environment are gaining greater importance. The key subjects in this field are environmental studies, biology, and geography. The following careers are available in this field.

1. **Ecologist:** Ecologists can be described as environmental biologist who study the interactions between organisms`and their environment and between organisms themselves.
2. **Genetics:** Genetics is the biological science that studies the way heredity qualities are transmitted. It provides an essential basis on which all living organisms, from micro-organisms to plants, animals`and the human race, are studied.
3. **Geologist :** Geology is the study of the material that constitutes the earth, the physical forces that act on the earth and the biology of its past inhabitants as revealed by fossils. This knowledge is used in the search for essential raw materials, but also for other purposes such as to ensure safe land usage and in the conservation of the environment.
4. **Ichthyologist :** An ichthyologist is a zoologist who studies the fundamental aspects of fish biology.

Greater emphasis on environmental studies can create huge amount of careers to the learners

as well to protect the web between the organisms , not being broken.

Mining Industries

At present, many millions of South Africans are employed in the mining industries. South Africa's mineral reserves are unequalled in the western world. The variety and quantity of its mineral products, of which many are strategically important, and the size of the mineral industry's research programme, make South Africa one of the greatest mining countries in the world. Mining requires a network of shafts and tunnels, which have to be designed according to geological information obtained from drilling. Rock pressure, the circulation of fresh air, the cooling down of warm working places, the draining and pumping of water and cementation are factors that have to be kept in mind in order to prevent the invasion and infiltration of water. The enhancing activities in the mines will provide numerous career opportunities to the science oriented learners.

5. CONCLUSION

The information era and the current pace of scientific and technological advances open the way for very many careers to the school leavers. It is important for more than 70 % of all employees to acquire knowledge in science to pursue the careers available today in South Africa. Though the knowledge of science has great significance in the labour-market, the majority of the learners in the South African secondary schools are not offering science subjects today. If this trend persists for long, it may be no solution to the unemployment problem.

To many learners school is irrelevant, without meaning, and not related to employment after school. However, school does provide certain basic skills which are necessary at work. These skills are not taught and assessed directly in the classroom, but are learnt indirectly from various learning areas. Great emphasis should be given to the skill developments since they are very important for progress in all kind of careers.

Introducing the career oriented science education in our new curriculum will possibly make the learners aware of various careers. Most of the learners are unaware of careers. Great publicity should be given to the career guidance. Educators should try not to only relate their subject matter to the world of work, but also personalise the subject matter so that the learners may focus the relevance of their present studies to their own lives now and in the future.

Lastly, the skills, physical capabilities, values and interests of the learners should be respected and developed as they are required in all sectors of the careers.

6. What I have learnt?

The research on science orientated careers made me to be aware of the careers. I am more knowledgeable, about the careers and their needs now. I can counsel anybody about the careers at any time. The above said was one of my prime expectations when I started the M. Ed course in February 1997. I am really glad that I have obtained it.

Earlier I thought only the academic qualifications are needed to obtain the employments. After this particular research, I have grown to know the importance of the skills, physical abilities, values and interests required for the careers.

I did not get enough materials to focus the status of the Science Education when I was assigned to do the Assignment 1 in February 1997. Today the research has enabled me to keep sufficient resources to enrich me. The research has provided me with a very good chance to learn and practise the Standard Deviations and the correlations.

In future I will not perform a survey or a research far away from my home or my working place. I am really interested in the researches now and if the time permits I will carry out some more researches in the near future.

My main weakness was considering my opinions as the only perfect ideas. I admit that my opinions, before corrections were superficial. The research made me to analyse others opinions too. In future, I will critically analyse the opinions from various sources before I come to any conclusion.

I was also weak in expressing the findings in English. My lack of proficiency in English may irritate or confuse the readers of this paper. Since English is my second language, I had been and still now, reading a lot of magazines, novels and periodicals to improve my language proficiency.

Though I read a lot of articles for my references, I did not pay attention to make note of the authors, publishers etc. I had to search the references again to look the above said details. In future, I will certainly write down the details of the articles, immediately the reference is over. I was not perfect in formatting the references too. I have seen the format of other authors and corrected mine.

The M. Ed course has provided me the chance to know about Internet and to learn through Internet. Internet helped me a lot in finding the references, statistics etc.

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8.1 APPENDIX 1

Please answer the following questions in the provided spaces. If the spaces are not enough please write on separate sheets.

1. What are the courses available at your Institute for the learners who studied physical science as a subject?

.....
.....
.....

2. What admission requirements are needed for the above mentioned courses?

.....
.....
.....

3. The knowledge of which components / sections of physical science are advantageous or essential to follow the above courses?

.....
.....
.....

4. What are the skills acquired through the learning of physical science are advantageous or essential to follow the above courses?

.....
.....
.....

5. What are the possible careers the learners can look forward on completion of the above courses?

.....
.....
.....

6. Justify the knowledge and skills acquired through learning of physical science are helpful to the above mentioned careers?

.....

8.2 APPENDIX 2

QUESTIONNAIRE

A. What subjects do you study now ?

.....

.....

.....

B. Why did you select these subjects?

.....
.....
.....
.....
.....

C. In your view, what are the ten-top ranked professions in South Africa? (Indicate the best as 1 and the least as 10)

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

D. Which profession you wish to obtain after completing your studies?

.....

E. Do you think your subject choices are appropriate for the above-mentioned profession? Why?

.....

.....

.....

.....

F. If your subject choices are not appropriate, why you did not choose the suitable subjects?

.....

.....

.....

.....

8.3 APPENDIX 3

LEARNER	ENGINEER	DOCTOR	TEACHER	ACCOUNTANT	PILOT	COMPUTER EXPERT	TECHNICIAN	NURSE	CHEMIST	SECURITY FORCE	LAWYER	MANAGERS	POLITICIANS	BUSINESS PERSON	OTHER
L1	8	10		5	6	3	9	4	7		1	2			
L2	10	8	1	9		7	6		5	4	3				2
L3	9	10		7	5		8	6	4	3	2		1		
L4	8	9		7	10	5		6		1	4	3		2	
L5	9	10		8	6	4	7	5	2	1	3				
L6	9	10		8	7	4	6	5	2		3				1
L7	9	10		3	8	7	4	6	2	1	5				
L8	10	9	1	7	2	8	6	4		3	5				
L9	10	9		7	8	6	5	3	1		4			2	
L10	8	10		9	7	4	6	5	2	3		1			
L11	7	9			10	8	5	6	4	2	3		1		
L12	9	10		1	6	5	7	8	4	2	3				
L13	9	8		10	6	5	7		3	4	2			1	
L14	8	10		7	6	9	2	4	1	5				3	
L15	9	10		7	8	4	5	6		3	2		1		
L16	9	10	1	5	6	8	7	4			3				2
L17	9	10		8	3	7	1	4	5	2	6				
L18	8	10		9	5	6	2	3	4	1	7				
L19	6	10		8	2	3	7	4	5		9			1	
L20	8	9		10	5	7	6	4	2	3	1				
TOTAL	172	191	3	135	116	110	106	87	53	38	66	6	3	9	5
S.D.	1	0.7	0	2.3	2.2	1.8	2.1	1.3	1.7	1.2	2.1	1	0	0.8	0.6

CAREER / LEARNING AREA	Language	Natural Science	Mathematics	Arts & Culture	Human & Social Science	Technology	Economics & Management	Life Orientation	Future Prospects
Accountant	1		2				3		
Accounting Officer	1		2				3		
Accounts Executive	1		2				3		
Actor	1			2				3	
Actuary	1		3				2		
Advertising Careers	2							1	
Advocate	3				2			1	
Aeronautical Officer	1	3	2						
Agricultural Engineer	1	3	2						
Agricultural Extension officer	1	3	2						
Agricultural Inspector	1	3	2						
Agricultural Technician		3	1			2			
Agriculturalist	1	3	2						
Agronomist	1	3	2						
Air Traffic Controller		3	2			1			
Airways Clerk	1		2				3		
Ambulance/Emergency Care Worker	1	3						2	
Animal Scientist	1	3	2						
Aquatic Scientist	1	3	2						
Archaeologist		3			2	1			
Architect		3	2			1			
Architectural Technologist		1	2			3			
Archivist				1		2	3		
Armament Fitter		3	2			1			
Armature-winder		2	1			3			
Art Editor and Critic	2			3					
Artist				3	2			1	
Assayer and Sampler		2	1			3		X	
Astronomer		3	2			1			
Attorney	3			2				1	
Auctioneer	3		2				1		
Audiologist	2	3				1			
Auditor			2			1	3		
Automotive Mechanist		3	1			2			
Baking Industry		2	1			3			
Banking careers		2	1			3			
Beer-brewer		3	1			2			
Biochemist		3	1			2			
Biokineticist		3	1			2		X	
Biologist		3	1			2			
Biomedical Engineer		3	2			1		X	
Biomedical Technologist		2	1			3			
Boilermaker		1	2			3			

Bookkeeper			2			3	1		
Botanist		3	1			2			
Branch Manager	1		2			3			
Business Economist	1		2			3			
Cabin Attendant	3			1			2		
Career									
Carpenter		2	3			1			
Cartographer		3	2			1		X	
Cashier	1		3				2		
Ceramics Technologist		2	1			3			
Chartered Accountant	1		2				3		
Chartered Secretary	3		2				1		
Chemical Engineer		3	2			1		X	
Chemist		3	2			1			
Chiropractor		3	2			1		X	
City Treasurer	1		3				2		
Civil Engineer			3	2		1		X	
Civil Engineering Technician		2	1			3			
Cleaner						2		3	
Clergyman	1			3			2		
Clerk	1		3				2		
Clinical Technologist		2	1			3		X	
Clothing Designer			2			3		2	X
Coal technologist		2	1			3			
Computer Operator			2			1		3	
Computer Programmer	1		3			2			
Computer Technician		2	1			3		X	
Concrete Technician		2	1			3			
Concrete Technologist		2	1			3			
Construction Supervisor		3	1				2		
Construction Engineer		3	2			1		X	
Copy Writer	3			2				1	
Costume Designer			2	1		3			
Credit Controller			2			1	3		
Crop Protectionist		3				2	1		
Customer Service Agent	3				2		1		
Dancer				2	1			3	
Data Typist	2					3		1	
Decor Designer			2	1		3			
Dental Assistant		3	2			1			
Dental Technician		2	1			3			
Dental Therapist		3	2			1			
Dentist	1	3	2						
Die-sinker		1	3			2			
Diesel Fitter		2	1			3			
Dietician		2	1			3			
Diver		2				3		1	
Domestic Appliance Mechanician		2	1			3		X	
Domestic Personnel	2				1		3		
Draughtsman		1	3			2			
Ecologist		3	2			1		X	
Economist	2					1	3		

Educator	1	3			2		X	
EEG-technician		2	1		3			
Electrical engineer		3	2		1			
Electronic Engineer		3	2		1		X	
Engraver		2	1		3			
Entomologist		3	2		1			
Explosives Technologist		2	1		3			
Extractive Metallurgist		3	1		2			
Farmer		3	1		2			
Fashion Buyer	2			3	1			
Fiberglass Worker		2	1		3			
Financial Manager			3			2		
Fire-fighter		3	1		2			
Fireman		2	1		3			
Flight Engineer		3	2		1			
Food Scientist		3	1		2			
Food Service Manager		2	1			3		
Footwear Technologist		2	1		3			
Forester		3	2		1			
Funeral Director	3					1	2	
Furrier			1		3		2	
Game Ranger		3	1			2		
Geneticist	1	3	2				X	
Geographer	1	3	2					
Geologist		3	2		1		X	
GeoTechnologist		2	1		3		X	
Goldsmith and Jeweller					3	1	2	
Grain Grader		3	1		2			
Graphic Designer		1	2		3			
Grassland Careers		3	2		1			
Grassland Scientist		3	2		1			
Health Industry Worker		3	2		1			
Herpetologist		3	2		1			
Home Economist			1	3	2			
Homeopath		3	1		2			
Horticulturist		3	2			1		
Hospitality Industry		1	2				3	
Human Resources Manager	1					3	2	
Ichthyologist		3	2		1		X	
Interior Designer			1	2	3			
Industrial Designer		2	1		3			
Industrial Engineer		3	2		1		X	
Industrial Technician:Hydrometry		2	1		3			
Industrial Technologist		2	1		3			
Inspector of Works		1			2	3		
Instrument Maker		2	1		3			
Instrument Mechanician		2	1		3			
Interpreter	3			1			2	
Inventory Manager	1		2			3		
Investment Manager	1		3			2		
Joiner & Woodmachinist		2	1		3			
Journalist	2				3		1	

Knitter									
Land Surveyor		1	3			2			
Landscape Architech		2	3			1			
Leather Chemist		3	2			1			
Lift Mechanic		2	1			3			
Machine Operator		2	1			3			
Machinery Mechanic		2	1			3			
Magistrate	3			2	1				
Mail Handler	1		3					2	
Make-up Artist				2		1		3	
Management Accountant	1		2				3		
Management Consultant	3		1				2		
Manager	1		2				3		
Marine Biologist		3	2			1			
Market Researcher	1		2				3		
Marketing	3		1				2		
Materials Engineer		3	2			1			X
Mathematician	2		3			1			
Matron	1			1			3		
Measurement and Control Technician			2		1	3			
Meat Cutting Technician		2	1			3			
Medal Jeweller		1	2			3			
Media Manager	2						3		
Medical Doctor		3	2			1			
Medical Orthotist Prosthetist		3	2			1			
Medical Physicist		3	2			1			
Metallurgical Engineer		3	2			1			
Metallurgical Technician		2	1			3			
Meteorologist		3	2			1			x
Meterological Technologist		3	2			1			
Microbiologist		3	2			1			
Miller		3	2			1			
Milliner	1			2				3	
Milwright		2	1			3			
Mine Surveyor		2	3			1			X
Mining Engineer		3	2			1			X
Moulder		3	1			2			
Musician	1			2				3	
Nature Conservanist		3	2			1			X
Nature Conservator(Zoo)		3	2			1			X
Navigating Officer		3	2			1			
Navigator		3	2			1			
Network Controller			1			2	3		
Nuclear Scientist		3	2			1			
Nursing		3	2			1			
Occupational Therapist		3	2			1			
Oceanographer		3	2			1			
Operations Assistant		2	1			3			
Operations Researcher		1	3			2			
Optical Dispenser		3	2			1			
Optical Technician		2	1			3			
Optometrist		3	2			1			

Oral Hygienist		3	2		1			
Ornithologist		3	2		1		X	
Paint Technician		2	1		3			
Patent Attorney	1	3	2					
Pattern-maker		2	1		3			
Petroleum Technologist		2	1		3			
Pharmazist		3	2		1			
Photographer		3	2			1		
Physicist		3	2		1			
Physiologist		3	2		1			
Physiotherapist		3	2		1			
Pilot		3	2		1			
Plaster and Tiler		1	3		2			
Plastics Technologist		2	1		3			
Plumper		2	1		3			
Podiatrist		3	2		1			
Post Office Clerk	1		3		2			
Postman/Postwoman	3		2		1			
Power Plant Operator		2	1		3			
Private Secretary	3		1			2		
Production Manager		3	2			1		
Productions Assistant		3	2		1			
Programmer			3		2	1		
Projectionist			3		2	1		
Psycometrist	3			2			1	
Public Administration Officer	1		2			3		
Public Relations Practitioner	3			1		2		
Purchasing Manager	2		3			1		
Quality Control Inspector		3	2		1			
Quantity Surveyor		3	1		2			
Radiation Protection Monitor		3	2		1			
Radiation Protection Officer		3	2		1			
Radiation Protection Specialist		3	2		1			
Radio Announcer	3			1			2	
Radio Careers- Technical Careers		2	1		3			
Radiographer		3	2		1			
Receptionist	3				1		2	
Recreation Manager	1					3	2	
Recreation Officer	1					2	3	
Refrigeration Mechanic		2	1		3			
Rigger		3	2		1			
Rubber Technologist		2	1		3			
SA Navy : Officer Training	1	3			2			
Sales Representative	3		2				1	
Sawmill Operator		2	1		3			
Scale Fitter		2	1		3			
Sea Transport Workers		3	1		1			
Secretary	3				1	2		
Sewing Machine Operator		2	1		3			
Sheet Metal Worker		3	2		1			
Shop Assistant	2		3			1		
Singer	2			1			3	

Soil Scientist		3	2			1			
Somatologist		3	1			2		X	
Speech-Language Therapist	1	3	2						
Sport Advancement Officer			1				2	3	
Sport Manager			1				3	2	
Spray Painter		3	1			2			
Store Manager			2				3		
Swimming Pool Superintendent		2	1				3		
Systems Analyst			3			2	1		
Tailor			3			2		1	
Teacher	1							X	
Technical assistant		2	1			3			
Technical Illustrator	2	1				3			
Technical Writer	3	1				2			
Technician		2	1			3			
Teller			3			2	1		
Terminologist	3			2	1				
Textile Technician		2	1			3			
Textile Technologist		2	1			3			
Tool-,Jig-andDiemaker		1	3			2			
Topographical Surveyor		3	1			2			
Tourist Guide	3			2	1				
Trade Tester	2					1	3		
Translator	3			2	1				
Travel Agent	3		2	1					
Treasurer	1		3				2		
Typist	2			1		3			
Valuer and Appraiser	1		3			2			
Veterinary Nurse		3	2			1			
Veterinary Surgeon		3	2			1			
Veterinary Technologist		2	1			3			
Viticulturist		3	2			1			
Watch Maker			1			3		2	
Water Service Works Technician		2	1			3			
Welder		2	1			3			
Wildlife Manager		3	1				2		
Wine-maker		3	2			1			
Wood Scientist		3	2			1			
Wood Technologist		2	1			3			
Zoologist		3	2			1			
TOTAL	154	482	412	54	20	387	137	74	
MEAN	0.53	1.7	1.4	0.2	0.1	1.3	0.5	0.3	
SD	0.86	0.6	0.6	0.7	0.7	0.9	0.8	0.8	

RHODES UNIVERSITY

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LITERATURE REVIEW

***" COMPUTERS IN SCIENCE TEACHING : A
REALITY OR DREAM "***

K. NADARAJAH

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SUMMARY

This paper focuses on the use of computers in education, in particular science education in secondary schools. After examining some trends in computer-assisted teaching in different countries, the paper analyses and discusses the issues for the benefit of the disadvantaged learners in South Africa.

1. INTRODUCTION

The history of ethyne gas provides an interesting similarity with the use of the computer in education. In 1895, ethyne gas was discovered and it was only used to produce light. Nearly after two decades of this discovery, researchers found that ethyne could be used to make plastics. In the end, ethyne was used to produce a substance which has had a much more far-reaching effect on society than burners of ethyne could have ever predicted. In many respects, the computer is being used in education much like ethyne was being used in the beginning after its discovery. Similarly, educators in the developed countries have made the obvious discovery that some of their past teaching methods can be transferred to the computer in the form of drills, tutorials and computer- managed instruction after seeing its capabilities in business and industry. And, like the demise of ethyne for lighting, the use of expensive microcomputers to support these applications on a mass scale is likely to drop dramatically when educators realise that there are much cheaper alternatives. But more importantly, many educators are using the computer as an educational tool, not realising the true potential of the computer. They continue to adapt computer technology to existing methods of instruction. The full instructional potential of the computer cannot be reached until the educators view the computer from a different perspective, much as ethyne was eventually viewed as a component of a building material rather than a source of light.

My literature review begins with the history of the use of computers in education. The first chapter views the change in purpose of the use of computers in education involving a variety of issues such as change in methods of learning, accommodation of rapid discoveries of computer peripherals. These are discussed in three phases.

The next chapter, the main frame of my literature review, explores the use of computers in science education. Current crisis in the South African science education is painted first and there after the need for an introduction of computers to rescue the science education is critically analysed. This analysis is elaborated in three sub headings namely, computer as an ideal tutor, computer simulations in science education and, new learning environment. The advantage of computer as an ideal tutor is explained by the following historical event: Alexander the Great benefited by having the brightest person in the known world, Aristotle, as the private tutor.

Today, possibly each learner can have access to a computer as a private ideal tutor with even more knowledge than Aristotle.

The advent of the simulations in the computer has reduced the strain of learning by abstract. It is now possible to use a simulation to demonstrate interactively with 3-D graphics to a class of students how particles are arranged in a crystal lattice, or how an earth quake happens. I performed some experiments with softwares containing simulations and the advantages are discussed in my literature.

The computer is not just another form of media like a film projector or videotape unit. These devices can dispense information but cannot react to the individual needs of the learner nor they can actively encourage the learner to achieve higher levels of cognition. The true potential of the computer is providing a medium through which the learner can learn through efficient interactions. The new environment, Internet, provides excellent experiences to the learners. The benefits of the new environment are discussed in detail.

Computers are used for educational purpose in a large scale in some technologically advanced countries such as USA, UK, and Australia in implementing Out Comes-based Education. Since South Africa is moving towards Out Comes-based Education, I felt that the references to experiences in these countries are very important for the future science learners in South Africa.

The next chapter, highlights some international and local experiences. The cases of Kenya, Zimbabwe, Yemen and South Africa are viewed to build up an argument for the use of computers in science education. Further it is fortified by a report on a research that was conducted in a senior secondary school in South Africa.

After a careful critical analysis of the introduction of computers in science education from variety of literature some valuable recommendations are expressed for future considerations. In conclusion I find that the computers are very powerful tools for science education, but I have also cautioned that computers by themselves cannot replace educators. They can only be used as effective tools in the learning of science facilitated by educators.

2. History of Computers in Education

Knowing the history of computers in education up to its current position will help us to assess the developments in this field. This will give us an insight into the changes and their purposes and help us in attaining our goals in education. In many countries including South Africa a paradigm shift in education is visible. This shift changes the teacher centred education to a learner centred education. The role of the computer in education also changing to accommodate these changes. The changes in the purpose of using computers in education are described in the following paragraphs.

According to Turkle, S., (1997) the goal of computer literacy in the past was teaching students how computers worked and how to write programmes; if students could understand what was going 'inside' the computer, they would have mastery over it. Now the goal is to teach students how to use computer applications, on the premise that if they can work with the computer, they can forget what is inside and still be masters of the technology.

Dunsby, P., (1995) reports that the Internet was used at the start in 1969 by US Defence Department's Advanced Research Project Agency for its decentralised computer network. After evolving for 30 years, today the Internet's huge information resources are accessed by more than 40 million users world wide for various reasons including educational purpose.

The following illustrations are described in the series of "The New Media and Learning" articles which are presented at a conference sponsored by The American Prospect at the MIT Media Laboratory in 1996.

Broadly speaking, use of computers in education has gone through three phases. In the first, from the mid-1950s to the early 1980s, the prime interests were the development of computer-assisted instruction(CAI) and the teaching of computer programming. Computers were thought to be "transparent" when the users could look beyond the magic to the mechanism. The first personal computers of the 1970s and early 1980s, like the mainframes and minicomputers, required users to know how to issue exact instructions. Someone who knew programming could handle the challenge more easily.

The second phase of development began roughly in the early 1980s, with the spread of personal computers, graphical user interfaces(GUI), and general applications software. PCs and general applications software made computing more flexible and easily adapted to different subjects and styles of teaching. The new opaque interfaces- the first popular one on the mass market was the 1984 Macintosh -represented more than a technical change. The Macintosh "desktop" introduced a way of thinking about the computer that put a premium on the manipulation of a surface simulation. The desktop's interactive objects, its dialogue boxes in which the computer "spoke" to its user, pointed toward new kinds of experience in which people did not so much command machines as enter into conversations with them. Users were referring to an ability to make things work without needing to go below the screen surface. In a culture of simulation, when people say that something is transparent, they mean that they can see how to make it work, not that they know how it works.

Unlike motion pictures, radio, and TV, computers were far more susceptible to both student-centred and teacher-defined activities. And as computers began to be used for communication and the development of new learning communities, they took on an entirely different character from the earlier technologies. The computer revolution of earlier decades has now turned into a communications revolution and opened up important new possibilities for learning.

These possibilities are all being extended in a third phase of development that has begun in the 1990s with the advent of multimedia, the explosive growth of the Internet and the World Wide Web, and the transformation of computing from a segregated activity into a ubiquitous part of everyday work, school, and home environment. The lessons of computing today have little to do with calculation and rules; instead they concern simulation, navigation and interaction. The very image of the computer as a giant calculator has become quaint. Of course, there is still "calculation" going on within the computer, but it is no longer widely considered to be the important or interesting level to focus on.

It is not unreasonable to imagine a time not too far from now where each learner will take his or her own portable computer to school. Given that there are schools in the developed countries now who expect primary school learners to take their own portable computer to school, and that the relative cost of portable computers is becoming cheaper, this practice may spread and become the normal practice in South Africa too. A child entering school today is likely to continue in school for at least another ten years, and in that time it can be expected that the child will learn through computers because of the tremendous change in the computer technology it may become affordable to all the learners. Bearing the above in mind, my literature review explores the possibilities and advantages of learning science through computers.

3. Computers in Science Education

It is well known that most countries, including South Africa, have many problems in science education. In South Africa, clear shortage in numbers of qualified science educators and the inferior learning methods, which are many years behind the times, are the key problems to mention. The National Teacher Education Audit (1995), commissioned by the Ministry of Education, reported that teacher training in South Africa was very inferior and that the whole system needed to be reformed. The report showed that many colleges of education failed to prepare student teachers for the challenges of the new South Africa and the 21st century. It further indicated that future improvements of science education is bleak due to the poor facilities and lack of adequately trained science teachers.

It is worthwhile, at this juncture, to note that South Africa is moving towards a learner centred out comes based education. In this system the responsibility of learning changes from teacher as it is in the traditional methods of teaching, to learners as the case of self learning and individual learning methods. The main tasks for educators in this new paradigm will be to facilitate and manage the process of learning instead of teaching the learners directly.

On the other hand, the world is being changed, to an extent that people cannot live without the benefits of the scientific inventions. If South Africa wants to face the challenges of the modern scientific world, rapid empowerment of the science learners is very important. Appropriate methods of learning and the provision of resources should be considered as the prime factors of such empowerment as they influence the development of learners' knowledge of, and attitudes towards science.

As science educators, we are challenged to accommodate the global changes in science education, we have to update our curriculum and our instructional methodologies to provide relevant and highly motivating learning experiences for our learners.

International experience has highlighted that computers can be, and have been, catalyst for transforming classrooms. Computers can be used in schools to achieve any desired educational outcome. For instance, if our objective is to reduce study time and yet improve the quality and quantity of what learners know, then computers are available for drill and practice. Alternatively, if the outcome is to achieve constructivist learning then the provision of advanced visualisation tools, real data and on-line access to tutors are featured in the computers. If educators adopt tools that are simple, durable, flexible and responsive to teacher-defined problems in meeting the demands of daily instruction, computers now increasingly meet those minimum requirements- but obviously, they can also do much more(Starr,P.,1996).

What is the role of computer technology in addressing the challenges of science education reform? An often repeated phrase in the learner centred educational world is; 'let's do science not learn about science'. Researchers involved in Apple's Information Technology for Science Education have found that advancement in hardware capabilities, user interface and software

technology allow learners to use computers as a transparent tool to explore the world around them (Apple Computer Inc., 1999).

The current literature review tries to evaluate in details the effectiveness of using computers in science education. Hawkrige, D., 1990, emphasizes the use of computers in classrooms as follows. Firstly, children should be aware and unafraid of how computers work, because computers are pervading in all sectors rapidly. Since schools prepare students for life, they should prepare them to deal with computers, which ought to be demystified. This can be called the '*social rationale*, because it deals with students' place in society.

Secondly, children should learn to operate computers, at least at a basic level. Manipulation of computers provide some confidence in their ability to control computers, and possibly lays the foundation for a career in computer science when they move into jobs. This is the '*vocational rationale*: computer education should be related to future jobs.

Thirdly, children will learn physics, art or any other subject better through computer-assisted learning. This is the '*pedagogical rationale*, calling for improved teaching and learning, and may well be the one that commands greatest support among educators.

Computers require students to do less memorizing of facts and more information handling and problem solving. Computers encourage students to learn by collaborating rather than competing with other students. Computers are seen as catalysts, enabling desired change in education to occur. This is the '*catalytic rationale*. Teachers will adopt 'more relevant' curricula and bring educational opportunities to a larger number of children.

Computer as an Ideal Tutor

All the above-mentioned rationale, without any doubt, have an impact directly or indirectly on effective science instruction. Computers can be used in schools to achieve any desired educational outcome. Of all the advantages that computers will deliver to science education, the best will be their capacity to act as individual tutors. In fact, the computer acts as an ideal private tutor because it provides exceptional advantages for science learning.

This ideal tutor is highly knowledgeable in all learning areas and it can guide the individual to courses more suitable to the learners ability. Dowlin, E., and Loertscher, D., (1999) report that the development of the search engines and the meta search engines in the computer technology is providing access to any information which is needed by the user.

Further, this tutor is aware of exactly what the learner knows this will prevent undue repetition, and provides individual attention with all the necessary instructions. Our learner, of course, would never fall behind because of sickness or absence; the private tutor would always begin the lesson exactly where the previous lesson had ended.

Our model private tutor can repeat and review a lesson as often as necessary without irritating the learner, while praising each forward step with an encouraging attitude. With individualised computer instruction, learners can get almost immediate help if something is unclear. It is evident that educational computers today have phrases like "Ask an expert", "Type a science

question” and “e-mail your questions” in order to assist learners. Learners can continue to show their lack of understanding until the problem is resolved without any fear of embarrassment or disgrace in front of their peers. When learners are unaware of their weakness or may not know the questions to ask, the computer will recognise their poor learning sides through its constant evaluations and assessments. In this situation other learners will be unaware of who requires more attention at a particular level or when an obstacle is slowing a fellow learner. Computers can provide quality instruction and diagnostic tests in different forms ranging from drill and practise to assessment(Sewell, B.,T., and Buirski-Burger, N., 1998).

Computer simulations in science

All these powerful characteristics are available in the computers which are designed generally for educational purpose. A prominent feature existing in today’s computers is the ‘simulation’ which is a very promising and unique application for science learning. Trowbridge and Bydee(1986) define computer simulation as 'a representation of the behaviour of a real situation or system. Computer simulations have been called dynamic blackboards' by some teachers, because the kind of information that they normally have to write labouriously by hand on black boards may be presented on a monitor in a dynamic flow capable of displaying the simultaneous effect of various factors and treating them as operator - dependent variables.

The question of simulation is posed from preschool through to university years. Why should four-year-olds manipulate virtual magnets to pick up virtual pins? Why should seven-year-olds add virtual ballast to virtual ships? Why should fifteen-year-olds pour virtual chemicals in to virtual beakers? Why should eighteen -year-olds do virtual experiments in virtual physics laboratories? The answers to these questions are often: simulations are less expensive; there are not enough science teachers. But these answers lead to a large question: Are we using computer technology not because it teaches best but because we have lost the political will to fund adequately?

Sewell, B.,T., and Buirski-Burger, N., 1998 report that computers are capable of providing simulations of science experiments which range from simple to complex. For instance, learning about quantum mechanics is difficult to many learners because of its abstract nature. Only computer simulation can provide visual intuitions about what it would be like to travel down a road at nearly the speed of light. Computer simulation makes it possible to play with different parameters and see how systems react in real time, providing learners an experience of " living physics".

I performed some simulative science experiments on my personal computer. Yue-Ling Wong’s Java Interactive Titration Simulation provides a rich learning experience in the topic of acid-base neutralisation in chemistry. It allows the learners to perform a simulative acid- base titration to determine the concentration of an acid by titration by using a standard solution of Sodium Hydroxide as titrant. Sodium Hydroxide can be added by drops of volume range from 0.1 to 5.0 mL. Simulation shows the change in pH graphically whenever a drop of

Sodium Hydroxide is added. Accurate end point is possible as the simulation allows to add smaller aliquots when closer to the end point. Variables, such as concentration, volume for acid and base can be adjusted by the use of a slide bar which is available in the simulation. Acid-base titration can be performed more accurately in less time without the fear of chemicals. Reacting adversely, in fact, a variety of activities and processes which are difficult or even impossible in science experiments can be simulated through computers.

A natural science reference book; Eyewitness Encyclopaedia of Nature V2.0 Ages 10-Up for Mac/Windows on CD-ROM featured with simulative live-action video is more than a research tool for young learners. When browsing through this informative, fact-filled CD-ROM, children will get excited about biology, zoology, ecology and more. There is no doubt, the learners will be highly motivated to learn natural science when these types of simulative softwares are available for them. Lauterbach, R., and Frey, K. (1987) indicate that learners' enthusiasm and motivation are increased by the contribution of simulations as they solve their problems almost immediately and provide instant feedback to their decisions.

A New Learning Environment

Interactions are vitally important for learning. Dunsby, P.,(1995) argues that exchanging information is the key to any definition of learning, and computers have been the central piece of the information age. As computer technology develops, communication through computers also develops and creates a path way for learners to interact globally with their peers and educators. Global On-line Adventure Learning(GOAL) network academy reports that its on-line classroom and electronic pen pal network connects 1.5 million learners and educators in 20,135 registered classrooms from 108 countries. Learners can easily locate their peers on many criteria including age, grade, curriculum, language and more.

After 50 years of controversy over the impact of television on children, a new world of on-line media is emerging that may have even greater impact on them(Montgomery, C. M., 1996). The new on-line media, a learning environment, is known as the Internet. Unlike television, online media are dynamic and two-way. This participatory quality makes them particularly compelling to children. Technological breakthroughs such as real-time audio, real-time video and virtual reality modelling language(which allows users to turn Web sites into three-dimensional environments) are transforming online media(Rheingold, H.,(1994). Through Internet children are being connected to a vast digital universe that goes beyond the family, the local community and even the nation. Education will expand beyond the classroom and other traditional settings, as more interactive ways of learning become available (Montgomery, C. M., 1996). Internet is a cultural phenomenon, a tool for uniting the world with powerful communication and a great instrument for access to information (Dowlin, E., and Loertscher, D.,1999).

Access to the Internet and the Web put students in reach of resources from the world's largest library and people that schools could never before provide. The new medium also provides access to audio and video resources, which conventional libraries generally do not offer. And, of course, the Internet provides not simply published resources, but also cyberspace - news groups and other forums for discussion; programmes for role playing and simulation. Groups of learners at different schools, even in different countries, work together on collaborative projects, comparing the results of environment studies or cross-cultural surveys and thereby learning not only the subject at hand but also other skills in social relationships. Through distance learning, both learners and educators can take courses in special subjects not locally available (Starr., P., 1996). Those without access to the communications system are likely to fall behind in education and be unable to compete in a highly selective job market.

Computer communications make contact, at whatever physical distance, easier and less costly. For example, learners now take electronic field trips to enter into discussions with people in specialised fields of work, to view exhibits, even to use the cameras and other physical instruments that are now being connected to the Web and that will increasingly enable learners in real time to enter into events at a distance and to participate in scientific experiments. This new electronic media can provide updated (up to minute) accurate information in seconds when a query is submitted to it (Rybicki, P., E., (1999). In reality, the information we get from our local libraries are months or even years out dated because we can't afford to maintain them with updated information. Further, searching for information takes seconds in the new environment as opposed to hours in our traditional databases. Further the colourful graphics and engaging interactivity of the new multimedia technologies will make the lives of children more powerful forces. If guided properly, the new media could enhance their drive to learn, provide them with access to arrive at a diversity of information and ideas, and enable them to reach across community and national borders. While traditional media are sometimes viewed as unnecessary diversions, digital media will soon become an integral part of daily life. The new media allows the users to do everything, that people do in real life, except leaving their bodies behind. According to Rheingold, H., (1994) through the Internet, people can exchange knowledge, make plans, brainstorm, play games, find friends, debate and share emotional support.

Globally, the new environment for learning, still has not had any general influence on schools. The many high-end uses of the new technology, like online courses in relatively, are appropriate for advanced secondary tertiary work but do not address the general needs of primary and secondary education. A study was conducted by Buck, J.H., and Horton, B.P., (1996) to obtain a broad overview of the use of computers in middle and junior high school level in Florida (USA), indicates that available technology is not being utilised. From the results of a national survey in USA, Becker, H., J., (1991) found that computers in many classrooms serve for occasional individual remediation and enrichment rather than a major learning environment. However, the new media, are becoming essential to intellectual and artistic expression and scientific work. As the entire world of communication and knowledge is transformed, it becomes inconceivable to leave education behind.

4.Educational Computers in the Developing Countries

Many developing countries are turning to computers in their efforts to build stronger economies and more efficient public services. Educational policy documents in some developing countries are increasingly stressing the importance of computer literacy to develop 'generic skills' and basic competencies in learning. However, a significant obstacle to attempts to integrate computers in education is the traditional tendency for disciplinary compartmentalisation and specialisation. The following chapter discusses the issues and quotes the cases of some developing countries, which are taking a lead in this field.

THE CASE OF KENYA

Kenya spends a higher proportion of its national income on education, and has relatively high percentages of its children attending primary and secondary school. Classes are large, 40 being common at the secondary level. Modernization is aiming the national goals for education. Government wants the schools to prepare children to use modern technology. Although Kenya's economy is agricultural, there is also a thriving business community, and a government system, both of which require technological support including computers. The educational system is meritocratic and strongly oriented towards preparing students for public examinations. Indeed, teachers are obliged to focus on the syllabus set for each subject, thus neglecting any teaching beyond it. Computer studies and computer science do not appear in the list of recognised secondary school subjects. There is no 'technology -led' curriculum.

In 1982 the Ministry of Education, Science and Technology decided to allow small experiments in computer education, both to gain experience and to produce computer-literate students. In 1988, Kenyan schools had about 230 microcomputers, of which about 140 were in privately-funded schools as part of external aid, paid for by donor agencies which also provided software and some staff training. There is concern that such aid will not continue, leaving the schools with expensive computers they cannot afford to run.

The Computers in Education Project of the Aga Khan Education Service (CEPAK) deserves special note. CEPAK was preceded by a small pilot scheme. Its originator considered that learning about computers and how to programme in BASIC were incidental to future needs of students. Computers should be introduced rather to improve instruction, revitalize teachers and give children experience of using them.

The pilot, based on the pedagogical and catalytic rationale, had ambitious targets: for example it was expected that teachers across the curriculum would be trained and become self-

sustaining in their use of computers by the end of the two-year start-up. This period proved to be too short: teachers needed more time to become secure in their use of the computers, to sample programmes, and to consider how and whether they could integrate these into their normal teaching. They also needed time to think through(and accept or reject) changes in their approach to teaching suggested by the software and by project staff. It soon became clear that students needed a course, too, on how the world of information might impinge on their lives.

"The pilot project was very thoroughly evaluated by researchers from the University of Nairobi (Gakuru and Kariuki, 1986) and reported on by Papagioannis (1985). The majority of teachers were using microcomputers and were willing to discuss ways of improving their teaching. Students were studying more in groups-some at computers, others carrying out other tasks and were discussing their work more. A few had become "computer experts" being able to operate the computers better than their teachers. Humanities teachers lagged behind. Programmes developed tended to be of the drill-and-practice kind.

Out of the pilot (by then called CEPAC Phase I), the main CEPAC project emerged, aiming to:

- improve the quality of teaching by in service teacher education using microcomputers as a catalyst.
- use microcomputers as a teaching resource in appropriate school subjects.
- provide pupils with a basic knowledge of information technology to help them in their studies and make them aware of their technological environment.
- improve the quality of school administration through the use of appropriate technology, and
- ensure that the schools become self-supporting in educational information technology through the appointment of appropriately trained staff"(Hawkridge, D.,1990)

Some educators in Kenya hold the view that children should learn about programming: others that they should know how to use computer programmes for accounting, graphics, word processing etc. There is also feeling that if children of the developed world can learn to use computers, so must children in Kenya in order to stay abreast of new developments. Among teachers, these views do not crystallize into a firm vocational or pedagogical rationale, though they may be made aware of both during training. Rather, there is a concern that using computers may deprive students of valuable time for studying the examination curriculum. Only a few teachers, think that computer science courses are a good way for students to get jobs in the computer field.

Teachers in Kenya express views about the disruptions they feel computers cause. Some teachers, for example, say that they do not like having to take classes to a special computer

room. Teachers, and their principals, also worry about the recurrent costs of using computers: they stop children from printing what has been compiled on the computers, because printing is expensive. Damage or even theft of hardware and software is a real danger in some schools, causing principals to insist on access being limited.

Parents are somewhat sceptical about their children's career prospects in this field, despite students' enthusiasm. Business nevertheless 'poach' teachers with computer-related skills: students with computer skills from schools like Starahé can easily get jobs. In some schools, boys seem more confident than girls with computers, and are keener to learn programming.

The research director of CEPAK notes the need for a national centre to provide continuing support for computers in Kenyan education. (Makau, 1987b). The future of computers in schools in Kenya is far from assured. Government policy is not yet fully established. Despite strong economic growth in Kenya in recent years, expenditure on education is not likely to expand sufficiently fast to allow for a full government-funded programme to put computers into all secondary schools, or even a majority of them. At best, it seems likely that resources will be allocated to a larger selected group than at present and that the work done so far will be sustained.

THE CASE OF ZIMBABWE

During the 90 years of colonial rule in Zimbabwe, the majority of the country's children received little or no education. After independence, the government allocated to education the largest percentage of its budget. Human and material resources were stretched to the maximum in the 1980s, and the Ministry of Education's priorities did not include computers for schools.

How remarkable it is that a number of secondary schools and a few primary schools obtained microcomputers and their staff showed such great interest in introducing them to the students. The students in turn, are enthusiastically learning to use them, whether to write programmes in BASIC or Logo, or for using business applications and educational software. Ministry policy appears to have been to encourage developments where these were funded from private rather than government sources. Ministry aimed at creating an awareness of information technology in secondary schools, was starved of funds despite its call for software and courseware to be written or adapted 'in Zimbabwe by and for Zimbabweans'.

Adoption of computers by the schools has come about as a result of at least two kinds of pressure: parents and principals have combined to raise funds to buy the equipment in a bid to increase the schools' prestige and modernity, and teachers have asked for it in order to be up to date professionally. There is no strongly and widely held rationale, although parents look anxiously to their children's job prospects. Most schools, especially those in rural areas, have difficulty in raising funds to obtain computers, although some have been given hardware and software by foreign computer companies.

The Ministry's Curriculum Development Unit appointed an officer in the mid-1980s to foster computers in schools, and for about two years (1985 - 87) circulated a quarterly newsletter, *Microcomputer Users in Zimbabwean Education*, containing contributions from teachers. Schools faced difficult hardware choices and obtained different types, with no hardware or software standard being set. In 1989 only a handful of schools were offering computer studies courses at Ordinary or Advanced level. A few offer their own course in information technology, in either the first or the last year of secondary schooling, focussing on some use of Logo and on teaching word processing skills. Almost all the computer-using schools run clubs, in which programming in BASIC is the dominant student activity.

"To serve the vocational rationale, one of the leading private boarding schools, Peterhouse, started by using Commodore 64s. Peterhouse decided against offering Ordinary-and Advanced-level computer studies: the timetable was tight already, and the syllabuses were more academic than practical. The school also wanted all interested students to use the computers, not merely the most able. To quote the rector (Peterhouse, 1988):

All the learners should know the elements of word processing and the use of spreadsheets. All should be able to make some use of the graphics facilities. In today's world such experience and knowledge is not a luxury: it is essential"

Peterhouse created its own information technology syllabus and now awards its own certificate with the approval of the Ministry and of the Computer Society of Zimbabwe. Students work towards the certificate in their own time, after the class hours. They become familiar with terminology, learn keyboard skills, gain some understanding of problems the technology can address and develop techniques for solving them."(Hawkrige, D.,1990)

In Zimbabwean computer education, it is true that almost all teachers do not see the relevance of computers to their work, and indeed teach in schools with no computers. Those teachers who are keen to use the machines are somewhat isolated and face some opposition. In addition to the fairly large distances between towns in Zimbabwe, schools have different hardware and offer different courses, and their teachers do not have much contact with each other.

Despite such problems, teachers' views expressed in the Newsletter in the early days of microcomputers in Zimbabwe were optimistic. Peterhouse teachers said: ' we seek to ensure that our pupils are aware of the part played by computers in the modern world and that they should not be mystified by or apprehensive of the machines. One mission school, Katenhe, began in 1986 with a battery operated Spectrum because the school had no electricity. The batteries were recharged at another mission some distance away.

The views of students and parents are influenced strongly by the threat of unemployment, the most serious problem facing Zimbabwe. In these circumstances, the vocational rationale is likely to prevail among students and parents alike. If their children can gain a significant advantage in job-seeking through learning how to use computers for work, parents are powerfully motivated to provide the funds to put computers into schools, with or without Ministry policy.

THE CASE OF YEMEN

Abdallah O. Al-Farra of Sana'a University researched the effectiveness of some current educational technology techniques on teaching chemistry. Three teaching methods were adopted: Instructional T.V., computer and teacher-class discussion. In the first two methods, instructional T.V., and computer, the student learned by themselves, i.e. individual and self-learning. On the other hand, the discussion method was carried out by a qualified chemistry teacher. The subject matter was the same for all students in the three groups.

The sample for study was drawn from the first secondary class(grade eleven) in two formal Yemeni School. A pre test developed by the researcher was conducted. After re-mediation, the post test was given to evaluate the effectiveness of each teaching method.

The first method was designed to teach a group of 15 students: the chemical concepts of this subject by the use of close circuit television. The circuit consisted of a television set linked directly by Video Cassette Recorder V.C.R. The teaching programme was developed by the researcher in television studio at the Faculty of Education, Sana'a University. The programme was based upon the self learning approach. The Scientific material was taken from the student's chemistry textbook. All the group members watched the programme together in one session. However, the design of the research allowed to replay the programme for several times.

The second group of 15 students used the computer to learn the same subject by the same approach. I.e. self learning but by the use of personal computer. The students of the researcher in the special Diploma programme-Faculty of Education developed the required computer programme.

The third group of students learned the same subject in the traditional way. Therefore, students in this group were taught the same content but by face to face teacher tutorial activity.

The findings revealed that the T.V. method obtained the highest scores followed by computer method then teacher-tutorial method. The researcher believes that there is a great necessity to adopt such new methods. The nature of our modern life, the great progress in science and technology may encourage this trend. Moreover, one of main reasons for adopting these new methods is the need for a huge number of qualified science teachers to face the incredibly increasing the population of the learners.

The researcher recommends, the new methods should be implemented as soon as possible, at least on experimental scale. However, it is also advisable to investigate in depth the conditions and basic requirements on terms of financial aspects, school buildings facilities...etc.

THE CASE OF SOUTH AFRICA

Information infrastructure in the African continent is the least developed in the world. Statistics from Jensen, M., (1998) shows the following situation regarding the information technology development in Africa at the end of 1998. Africans have the least access to computer equipment, the most primitive information networks, and the least accessible media systems.

But this is to exclude South Africa. Around one million Internet users in Africa, of which more than 85% are located in South Africa. Generally Internet access is concentrated in capital cities of African countries, except for South Africa. United Nations Economic Commission for Africa in 1996 reported that South Africa was ranked 16th in the world in terms of the numbers of Internet access.

The above indications are very much promising and encouraging the computer-based education in South Africa. The 13th Commonwealth Conference of Education Ministers report says that historically disadvantaged educational institutions in South Africa are still far behind in the information infrastructure and they are almost similar to the universities and schools in other African countries.

Some educational institutions have been privileged to develop information technology in South Africa as the beneficiaries of decades of segregation. I would like discuss, some recent developments in the computer-based instruction from such institutions in the following paragraphs.

The following computer-assisted science learning programme of University of Cape Town is briefed from its “ Electronic Science Tutor” review.

The introduction of computers in the University of Cape Town for educational purpose was started in 1985 with the development of a series of computer-based tests, covering the second year B.Sc. Biochemistry syllabus. At that time computers controlled the presentation of tests, recorded the student marks and enabled students to communicate with lectures using e-mail. It was UCT’s first venture of computer-based education and its success encouraged a number of activities in departments ranging from Construction Economics and Management to Chemistry.

In 1988 a programme was created on similar principles for senior secondary school students studying Physical Science. The programme had been developed and published as “ Physical Science Revision for Stds 9-10” in 1994. The name was changed to “ Electronic Science Tutor” in 1997 to point the applicability of the programme to a wider audience.

The initial design considerations, expressed in 1988 were:

- * The programme would cover the whole Physical Science(Higher Grade)curriculum for Standards 9 and 10 in English and Afrikaans.
- * The programme would run under DOS on all compatible hardware with appropriate Computer-based Education techniques.
- *The programme would be a revision aid and not a substitute for a teacher or textbook.

The main objective of the programme was to help learners in revising for their matriculation examinations. However, the programme was useful in a variety of learning situations. To provide comprehensive and supportive learning environment, two additional tools named as”topic reviews” and “ management system” were designed.

At present “electronic Science Tutor” is an extensive revision aid supporting the Physical Science (Higher Grade) curriculum, which has the following aspects.

- * Contains 60 topics includes a review of each topic.
 - * Tests each topic and provides the learner with feedback.
 - * Ensures the progress in learning by keeping detailed records of test results.
- Simulations, interactive worked examples and original graphics are some special features of this programme and they are found to be very helpful in science learning.

The heart of the programme has tests on each topic. The questions are designed to test the material in the syllabus at different levels. Important features of the tests include:

- * Questions are selected from large banks.
- * Use of different kind of questions such as multiple choice, single word input, proposition evaluation and numerical input.
- * Immediate feedback
- * Analysis of performance by question category
- * Sequence, recycle and drill test modes.

The purpose of the management system is to enable learners to measure their progress and educators to monitor the progress of learners. This provides an incentive for learners.

The programme is being revised and improved continuously in accordance with the changes in curriculum and the learning methods. The programme is being used by more than thirty schools and university academic development programmes. Their intention is to provide quality courseware in Physics and Chemistry which supports learners and educators by fulfilling their real needs.

Future versions of “Electronic Science Tutor” will include more simulations, photographic images, sound and video and additional management functions. It is also expected that the details of the new curriculum (curriculum 2005) will be available in due course.

The research Institute for Education Planning (RIEP) of the faculty of Education at the University of Orange Free State has as its objective the support of black education systems within the South African context, one of the main operational areas is the upgrading of science teachers which is sponsored by the private sector. Educators and education planners have attended workshops and in-service training courses offered by the Research Institute. During the presentation of these courses several problem areas were identified. In an attempt to remedy at least some of the problems experienced by black science teachers, computer-aided instruction was seen and investigated as a possible solution. A recent development in the search for more efficient training methods involved the integration of computer-aided programmes with existing in-service training programme for teachers.

The problems related to inadequately qualified black teachers of physical science in South Africa, the RIEP has started to develop computer software in physical science which may be used by teachers during in-service training courses. Simulations have been used especially to demonstrate the usage of apparatus. The software can be effectively employed for the purpose of revision exercises, demonstrations and the conducting of experiments and they can be of

great benefit in the school as an aid to the teacher, for individualized instruction of pupils, and for the in-service training of teachers(Van der Wal, R.W.E., and Van der Linde, H. J., 1992).

Internet BioEd Project is an initiative of University of Western Cape(UWC) aiming to make use of the Western Cape Schools Network(WCSN) to gain access to resources through Internet by schools that are part of the WCSN. The pilot project has the following intentions.

- * To determine the needs and required skills of teachers and pupils to make them access the resources.
- * To provide training to allow pupils and teachers to develop the necessary skills.
- * To develop and make available a collection of resources which pupils and teachers can use once they have gained the necessary skills.
- * To evaluate the quality of these resources and to improve their effectiveness in the teaching and learning of biology and environmental education in the selected schools.
- * To spread the use of the improved resources to other schools.

At present, the project makes question banks available to learners and it provides on-line resources via the world wide web. Through this project, biology students and teachers could exchange ideas, and discuss questions and issues related to high school biology and environmental education.

In addition to the above initiatives from the universities in South Africa, there are many Internet based educational projects such as Cyber School Africa, Learning Channel Online, Wake Up Genius, Interaid and Shoma Education Foundation, recently started to assist the secondary school learners and educators. They all are working to develop innovative uses of computer technology in education. Role of some of the above-mentioned projects are stated briefly below.

Cyber School Africa started in 1997, to offer a web-based exam revision guide for South African matric learners. This programme is a supplement to the present traditional learning and teaching system. However, this web-site is also useful to large numbers of overseas web-site visitors. This pilot programme proved to be extremely successful with more than 1000 user sessions recorded in its first month. Keen interest of the users contributed to the development of this project to become a more comprehensive web site in 1998 and to relaunch the Cyber School Africa site as a new and improved world-class educational web site in July 1999. It intends to develop virtual community among its users by providing dynamic communication facilities.

Power Science is a computer-aided Instruction(CAI) for science learners. It is developed by experienced science teachers since 1990 as a part of Wake up Genius web-based teacher supplement. Dynamic interactive tuition, examination papers and their solutions are the main features of Power Science. Learners can easily navigate through this software as it requires only some basic browsing skills. The rare quality of this product is reflected by the graphics provider for every experiment and the graded questions for both the weak and the strong learner.

Shoma Education Foundation uses multimedia technology to assist educators who are struggling to implement out comes based education in the South African schools. It provides

a three-phased approach that uses satellite, the Internet and collaborative lesson to ensure educators acquire new skills which are highly required in the new paradigm.

In contrast a research was carried out by Nadarajah, K., 1998, in one of the disadvantaged schools in South Africa. The aim of the research was to investigate how computers contribute to learners' skills development in a physics course. A series of interactive computer simulations of colour mixing and a number of closely related traditional practical activities are aimed to promote learners' understanding of colour. Learners mixed the colours in the traditional way, referred as experiment 1 and they mixed the colours with the use of a computer, referred as experiment 2. Demonstration of skills of the eight learners participated in four groups were observed and analysed. Findings from this research are discussed below.

The selected learners and the educators were very keen and co-operative when performing the experiments. Learners performed both experiments in groups while the educators performed only the second experiment individually. Interestingly, learners compared with educators, were more active and enthusiastic when performing experiments using the computer. Learners working in groups may be the reason. Both educators expressed during the interview, they would have done the experiment 2 better if they were in a group.

Problem Solving Skill

Computer way of mixing the colours has given the better rate of problem solving activities. It is clear that computer operations are much faster than the manual operations so that the computers provide more opportunities to the learners in these activities.

The experiment 1 has given more opportunities to the learners to be engaged in the sub problem solving activities. But learners were less concerned about this problems and did not take this problems further up to find the solutions. Manual way of mixing the colours creates number of other sub problems and it makes the learners to interact with other materials. Learners indicated in the interviews, that manual way of mixing the colours is problematic and time consuming, it clearly shows that they identified the problems.

Observers mentioned, in the interview, that the computer way of mixing the colours did not provide as many chances of identifying sub-problem solving activities as the traditional method. Video replay shows that traditional method makes the learners to deal with many equipments and materials. The use of many equipments and materials lead the learners into many sub-problem facing situations. When the learners perform the same experiment on computers, these chances are very limited, because they work in an ideal situation. Traditional way of conducting experiments are excellent in providing sub problem-solving activities to the learners. But in contrast, the traditional way experiments are weak in facilitating the learners to arrive at solutions if there are many sub-problem solving situations. Computer way of learning, facilitates the learners to continue further with their identified sub-problems to arrive at solutions. This view was also supported by the observers during the interview.

In problem solving, in the traditional method, the learners needed greater assistance from the educators than in the computer method. The reason being in the computer method only a few problem solving situations arose and the learners' eagerness in handling the computer, and ease with which trial-and-error method can be used in computer enable them to find the solutions to these problems by themselves.

Investigating skill

Once again the experiment 1 has given lot of chances to the learners to develop their investigating skill. In reality experiment 2 made the learners to be involved in the investigating activities much more times than experiment 1. During the interview with the educators, they expressed their opinion that computers provide solutions to the learners' investigations in a very short time. It automatically makes the learners to engage more in the investigating activities. Learners mentioned in their response to the questionnaire that the interesting feature in the computer way of mixing the colours is the 'instant answer' to their investigations. They were of the opinion, that computer provides simple and shorter procedure for performing experiments. Learners responses reflect that traditional way of conducting experiments are not welcomed by them. Further, most of them stated if they have a chance to perform all the experiments on the computer, they would prefer to avoid the traditional way.

Surprisingly the groups with weaker (in terms of their classroom and examination performance) learners performed well in the computer method experiment. Educators confirmed this findings in the interview. Similar research was carried out in the University of Western cape. The report says, "University of the Western Cape students typically come from varied academic and socioeconomic backgrounds. Many of the students are from educationally disadvantaged communities and nearly all of these are first generation university students. In general these students will have had little exposure to technology..... Initially it was assumed that students with mathematical ability and those who had no fear for technology would be successful candidates in the Electronic Data Processing course. Contrary to our expectations no correlation was found between the results of the statistics course and the more practical Electronic Data Processing course. Students with a fear for technology achieved higher marks (Venter, I.M., and Blignaupt, R.J., 1996)

Communicating skill

Number of communications involved in learning the concepts were counted in the both experiments. Explanations, instructions, discussions and consultations by verbal or sign language between the learners or between the learner and the educator are considered as communication activities. Recorded video was played during this process, observers and the researcher combined together in formulating the communication activities.

The results show more communication activities were involved in the computer way of mixing

the colours. In experiment 1, teacher intervention was in the form of assistance to the learners. Number of times learners were assisted to help them to proceed with their experiment. Most of the time, the educators were instructing, explaining and talking to the learners. The learners were, by themselves, not sharing their ideas, not helping each other and not expressing their potentials in a supportive learning environment. In contrast, the teacher intervention in the second experiment was in the form of inducement. During the procedure, the learners were given extra tasks of more difficult nature to induce them to increase their communication level. Observers noticed that the learners became more active in the learning process which lead to more effective communication in sharing of ideas and helping each other. In a similar situation, learners completed their tasks without any outside help, gained highest scores(5 or 6 in a scale of 0-6), with 50% teacher help gained medium scores(3 or 4) and with over 50% teacher help gained lower scores(1 or 2) for skill developments(Journal of Computer Assisted Learning; May 1998; volume 15; page 78). The research findings and the above literature show that, constructive teacher intervention in the form of inducement is necessary to achieve higher level of skill developments.

Computer hard ware used in this research were the key-board and the mouse. There were many operations in the computer that could have been executed either by using the mouse or by using the key board. Learners showed confident in handling the mouse for various operations while the key-board for the same operations was rarely used to execute these operations. As the computer could be operated by only one learner at a time, the two learners had to take turns to operate the computer, but they had to communicate to complete the task. This arrangement provided a better chance of learning through communication and enhanced the development of communication skill.

In conclusion, the type of software, teacher intervention, composition of the group, amount of task and the type of tasks have an effect on the learners' communication.

Attitude towards the experiments

Assessing the attitude is the most difficult task in these type of experiments. When a new way of teaching is introduced, due to the curiosity learners immediately jump to welcome the "new comer". Is this attitude long lasting?

Most of the learners and educators strongly indicated that they are not afraid to use the computer in their practical work. Learners and educators mentioned that a week of training in computers changed them to be aware and unafraid of how computers work. If the computers are introduced in the science curriculum there is no doubt, the *social rationale*, argued earlier will be achieved. Learners strongly agreed the computer helped them in organising the practical work, presenting the practical work and to perform more interesting and imaginary work. They also mentioned the computer allows them the self discovery learning and they do not need an experienced teacher nearby. Learners indicated that they want to do more experiments with the computer and they are confident in handling the computer.

Educators views were different from learners, they argued even the traditional way of conducting the experiment gives the equal chances like computer in organising the practical work, presenting the practical work and to perform more creative work. Educators were supporting the learners, in the view of the computer allows the users the self discovery learning. They mentioned, though the learners get the solutions in good time when the experiments are carried out with the computers, experiments are incomplete in the sense that they only used the visual-sense. They viewed that the computers are really helpful to the learners when the experiments are impossible to do in the laboratories because of the resources, time etc. Educators pointed that the learners do not need an experienced teacher nearby, when they are performing the experiment with the computer is suitable only for experiment 2 type situations which do not involve many variables.

By performing the experiment with the computer, the learners are able to experience each stage and each movement of the experiment. They are also directly involved since they can witness all the chances which occur. By using the computer, the pupils conduct and observe the experiment under ideal conditions which are not possible by traditional experiments.

Computer-based experiment was 'owned' by the learners, even if the educator made some suggestions and raised tactful questions. It has given an opportunity to build on the learners' existing knowledge and also to glean information by personal research. Computer-based experiment, among other reasons, provided a successful and satisfying outcome for the learner to enjoy much.

A similar study was conducted at the University of the Western Cape by Venter, I.M., and Blignaut, R.J., in 1996. Their report shows almost the same pattern like the above findings in an attitude survey. Finding states that the majority of the learners found working with computers enjoyable and stimulating. For example, 74% agreed that they could learn a computer language, 69% felt at ease in a computer class, 66% felt comfortable working with a computer, 51% agreed that they could get good grades in a computer course, 80% thought it is important to do well in a computer class and 72.8% said that computers do not scare them. Frequencies of the pre-questionnaire indicate that 76% of students felt positive about computers and computer applications. Only a few students had reservations about technology before they did the literacy course. For example 17% of students felt threatened by computers, 21% agreed that computers made them feel uncomfortable, 21% felt they could not handle a computer course, 20% agreed that computers rob people of their individuality, 18% felt that computers are used to manipulate people, 18% considered learning about computers a waste of time and 26% felt aggressive and hostile towards computers.

The report further says that the University of the Western Cape(UWC) students typically come from varied academic and socioeconomic backgrounds. Many of the students are from educationally disadvantaged communities and nearly all of these are first generation university students. In general UWC students had little exposure to technology. Initially it was assumed that students with mathematical ability and those who had no fear for technology would be successful candidates in the Electronic Data Processing course. Contrary to their expectations no correlation was found between the results of the statistics course and the more practical

Electronic Data Processing course. In UWC students with a fear for technology achieved higher marks.

5. Critical Analysis and Recommendations

"Future computer networks for education in the twenty-first century appear to assume extensive worldwide networks which use the processing power of the computer terminal to enhance the value of the multimedia information transmitted. Current systems in the UK have pioneered valuable work, but because of inherent design problems of the present central systems and the move towards local management of schools, current global interconnections may be restricted to a few pupils in a few schools."

(Davis, N.1993)

Very soon the computer will be the 'complete' educator. To choose the best method of teaching from the different modes of educating the learners such as T.V., Video, Audio, Computer and the traditional teacher-chalk board, will not be needed any more in the near future, because the computer does all these together. To day the computer is the fast and most knowledgeable, up to date information provider to the learners. When the computers are connected to the advanced net work systems, learners will be able to see and talk to the subject experts miles away from them as well as the learners can communicate among themselves. Niki Davis, describes in his paper, choice of a video through a terminal which displays six video clips simultaneously in high resolution on the screen and enables the user to search videos by theme or other key words. He also describes " Tell Me More Television" transmitted by cable, in which the viewer browses, at will, through hours of interest and can seek elaboration on specific points.

In the UK a few systems which support electronic communication within compulsory education, which allow the users, on payment of subscription, to be connected to central computer which manages electronic mail and possibly databases and computer conferencing too. This central computer can open gateways to other host computers in the UK and abroad. Such systems have supported some fascinating and valuable education: for example cultural exchanges, an electronic 'writer in residence' and collaborative collection and interpretation of scientific data across schools and countries. (Keep, R.,1991)

When the learners are given the opportunity to communicate through the networks, will be exposed to many activities which are needed to construct their knowledge in a learning area. Some experiments in science, which are impossible to perform in a class room situation, can be effectively carried out through the computer simulations. Computers are also providing, the learners, the opportunities to explore the interesting fields in depth.

Our current system of schooling reflects the industrial age, so we need a new approach to learning in the information age. The introduction of computers into classroom promotes a

greater emphasis on projects, with educators acting as facilitators and learners taking on a central role in their own learning. Computers can make a shift from all learners learning the same things to different learners learning different things and from the primacy of verbal thinking to the integration of visual and verbal thinking.

The Cost of Computers

The new technology of today is tomorrow's old technology. The technological advancements, accelerates the production of computers, more than the demand, create a lot of confusion among the consumers. Today we can purchase a computer, with 1000 times more advanced features and 10000 times faster for less than the price a computer a decade ago. In mathematical terms, the computers today, are more than 10 million times cheaper!

" These 'palmtop' machines are portable in a way that even laptops can never be. Eight palm top computers can be carried in a small box, and there are no leads, no plugs to worry about(the pocket book runs on two 'AA' batteries and a 3V lithium back up) and no noise. The children and teachers have flexibility of workplace, work space and work style. Children were able to type, interrogate, discuss and read whilst on the move. Children in the special school appear happy to work at a table or rest the palmtop on a knee or bag. Palmtops were passed around groups during science and English activities..... The issue of cost is closely tied to size and portability. For the price of one desk top machine a school can have 6-8 palmtops. Thus we have moved from a situation of one computer shared by whole class to one where normal group organisation can now be targeted at computer use. Access (in terms of time) for children increases by a factor of at least five(in some cases much more)" (Cross, A.,1994).

Yet just as access is becoming urgent, the number of children living in poverty without access to technology, is growing at an alarming rate. In sufficient funds in the Department of Education may leave many communities and vast majority of schools unconnected. Even if some children in the wealthy private schools are able to use the new media through schools and libraries, they will still be disadvantage to children with access at home. An hour or two of computer access in school is not enough to acquire the technological competence that many jobs will require. Some argue that costs of the equipment will go down dramatically in the next few years, making computer communications as affordable as radios, televisions and VCRs. But monthly service charges and communication(local telephone call) charges are other barriers to make the majority of the learners unconnected to this new media of learning.

Purchasing the educational softwares are very costly. Local production of these softwares are unlikely at this time because the technology in this field is not yet developed in South Africa. If we are really looking for the local productions, we should make our learners aware about the IT by introducing the computers in their school curriculum. The exposure to the computers will lead our learners for tomorrow's technology, to produce the soft wares for our needs with confident. Until such technology develops, our learners may use the inexpensive networks to

gain knowledge and skills.

In reality, all the science experiments are not possible to execute in our existing laboratories. Construction of laboratories for each and every school to cater for the science experiments will consume the largest sector of the national budget. Computer simulations are cost effective in terms of science experiments at our schools. Further more, all the experiments in science can be performed in the manageable time-span.

Benefits of Computers in the Classroom

The following may serve as a guideline regarding possible uses of the computer in the classroom:

- The computer can be used to introduce the subject matter to be discussed in the lesson. As the introduction to a lesson is of the utmost importance a good and effective introduction will determine whether the pupils will be motivated to listen attentively to the rest of the lesson.
- Computers can make the learners more engaged with their activities.

- The use of computers can also help address another obstacle to change-standardised achievement tests. To prepare learners for those tests, schools can make use of the more didactic forms of computer-based education without organising their whole programme on that basis.

- Computer-based education may help to create effectively smaller classes. Empirical studies indicate that learners in large schools take part in fewer school activities, identify less with the school, and have lower scores on achievement tests than do learners in small-sized schools. The small class size permits closer relations among educators and learners and thereby fosters the kind of unified educational vision that researchers have repeatedly identified as a key to successful schools.

- Members of different racial groups may learn more through interactive software or online services because they sense no stigma or disapproval.

- Computer networks improve access to educational resources for those in small communities and rural areas. Likewise, computers and computer communications enable people with disabilities to gain access to resources otherwise unavailable and to take part in groups without hindrance or stigma.

- The computer may be used for drill and practice. Several appropriate questions on the work to be revised may be selected from a question bank by means of the computer in a very short time.
- The computer can also be used to demonstrate difficult concepts and ideas, which may be explained effectively and repeatedly with the aid of the computer.

- As already discussed, experiments may be demonstrated on the computer, or the learners

may be allowed time on the computer to do the experiment themselves. Computer simulations are best reserved for those experiments which cannot be conveniently performed in the school situation.

-Demonstration of practical applications of the theory, i.e. bringing the factory to the classroom. The extension of theory into practice is a very important facet of the teaching of science, but often the theory learnt can also be applied in practical situations which can only be demonstrated to the pupils by means of computer simulations.

The Learning Possibilities in the Computer Simulations

- Very complex experimental techniques that would require expensive equipment, inordinate amounts of time and/or extremely long complex process, can be carried out. Eg. Millikan's experiment
- Experiments of very long or very short duration can be altered to fit in the school timetable. Biological reactions are extremely slow: in a computer simulation these time-spans can be reduced to manageable periods.
- Computer simulations are very useful where certain dangers are involved, such as the use of toxic chemicals, rapid or explosive chemical reactions, or other natural processes which would make the experiments far too dangerous to be carried out in a typical chemistry laboratory.

6. Conclusion

The history of ethyne provides one final insight into the role of the computer in learning. Ethyne is used to make plastic, a term which originally meant "formative, fashioning, creative" In a sense, the computer is "cognitive plastic", able to be formed in any manner we choose to assist us in the learning process. Until educators and learners alike appreciate this fact, we will continue to waste, rather than exploit, the uses of the computer in education. Society could afford to wait several years for plastics but it can ill-afford to wait as long for curriculum developers to discover the best uses for computers in education.

The educational community must press for the needed changes to overcome the failure of education to meet the needs and hopes of most South Africans. Educators must demand computer-based materials which encourage experiencing and integrating. They must learn to use these materials in the most effective manner in their classrooms. They must push educational researchers to provide the needed guidance and direction.

The Minister of Primary and Secondary Education for Zimbabwe, Comrade Fay Chung, Said:

"Computer technology is going to change ways of teaching and possibly challenge the manner in which we think about schools "

(Zimbabwe Herald, 23 May 1988)

To achieve the educational goals in the short time span, technical way of teaching may be introduced. Since the new curriculum is not rigid, the possibility of accommodating the " new methods of teaching" can be explored. As we are entering to the OBE era from our traditional educational system, the possibility of introducing computers for education, in particular for science education should be experimented. A decade ago computers and related technologies were considered as luxurious and it will be available only for the first world. Today the image is changing due to the over production of computers and components. Tremendous advancement in technology around the globe provides cheaper access to the information technology.

In Science teaching, computer-based experiments offer science educators a powerful technology to enhance laboratory work, often more exciting and meaningful to learners. Computer cannot replace the educator completely, but it can be used as an effective tool or as a facilitator in the process of learning. Learners can explore science phenomena in more accurate and precise ways than are possible by traditional experiments - at least for certain experiences which are not possible in the classroom teaching. The computer simulation as a laboratory tool, provides higher rate of skill developments to the learners and to focus on data almost immediately.

Information technology can be a remedy to the de-motivated learners and educators in South Africa to change their attitudes in a constructive way, which is highly needed in the effective science teaching today. The most difficult task in implementing the computers for science education is to convince the educators about the change in method of teaching. If this task is not persuaded among the teachers, information technology for science education will be a dream.

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