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Evaluating a web-based computer package to help teachers use a science-technology-society (STS) approach to teaching human population dynamics

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CHAPTER ONE

THE CONTEXT OF THE STUDY

1.1 INTRODUCTION TO THE PRESENT STUDY

This study describes the development and evaluation of a web-based package that was designed to assist teachers in using the Science-Technology-Society (STS) approach to teaching human population dynamics in South African schools. In order to improve on the web-based package, the package was evaluated using questionnaires and expert review. The information obtained from these methods was used to modify the package. Literature was reviewed on the problems experienced with teaching human population dynamics, requirements and demands of *Curriculum 2005*, Science-Technology-Society approach to teaching as an alternative method to teaching, the benefits of using computers, the theories of learning and professional development.

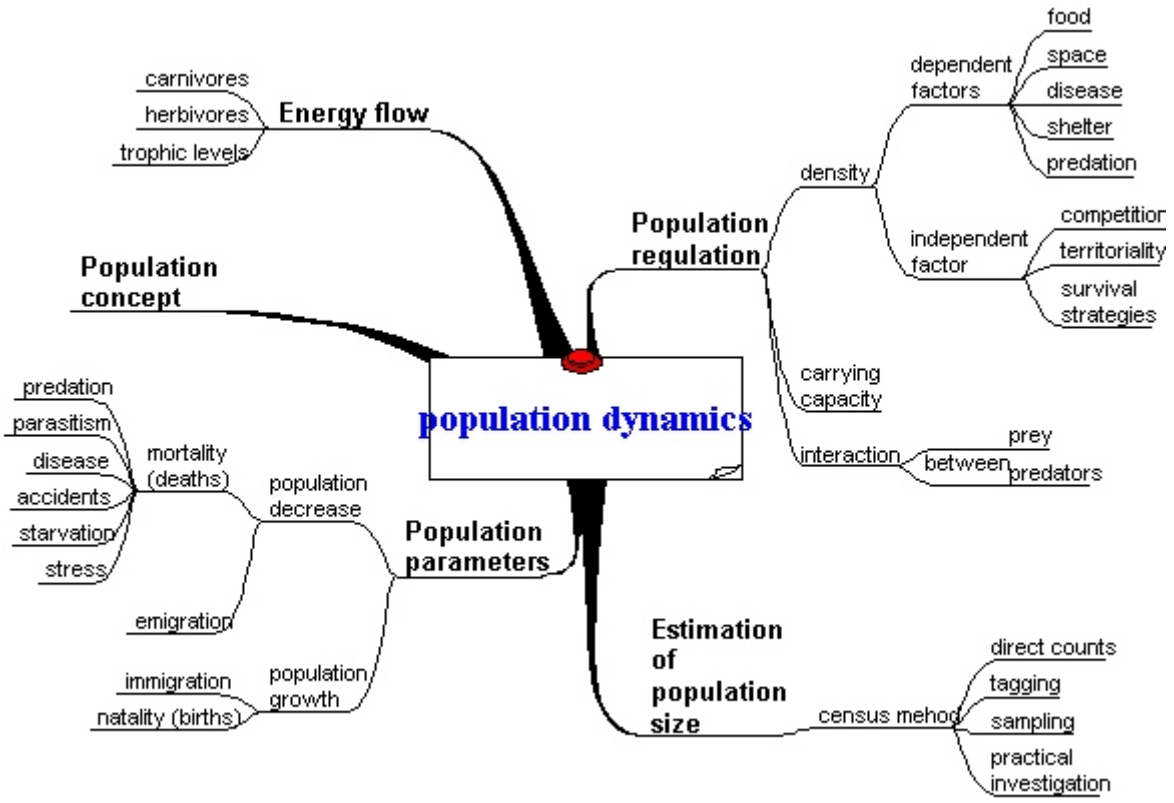
1.2 STATEMENT OF THE PROBLEM

Several educators claim that the biology curriculum in many countries is too theoretical and lacks relevance (Hurd, Bybee, Kahle and Yager, 1980; Hart and Robottom, 1990; Kumar, David, Berlin and Donna*.,* 1996). In the USA, approaches to the teaching and learning of biology even in the 1990s are often textbook-centred and discipline-bound with little relationship to experiential learning, the personal needs of learners or societal issues (Hurd *et al.*, 1980; Hart and Robottom, 1990; Yager, 1993; Yager and Lutz, 1995). Research shows that South African schools also tend to follow a teacher-centred approach (Naidoo*,* Kruger and Brooks, 1990) and some researchers claim that schools concentrate on presenting concepts and principles based on an outmoded curriculum, which is too academic and which many teachers present in a way which lacks relevance (Singh, 1998 and Hockey, 1995).

A teacher-centred approach to teaching emphasizes the learning of facts so that learners can pass their examinations (Hockey, 1995). Most teachers emphasise their teaching on the final external examination, which has influence on how they teach their subject area. According to Naidoo *et al.,* (1990: 7) and Hockey (1995), *this teacher-centred approach to teaching has shown itself in classroom scenarios of discipline-bound, uncritical, transmissive teaching practices and behavior manipulation of learners through the use of textbooks and rote learning.* Hockey (1995:41) also argues that the pedagogy that teachers in South Africa tend to follow is predominantly teacher-centered, and traditional in its approach.

This teacher-centred approach can be seen in the teaching and learning of population dynamics. Human population dynamics is currently taught in the matriculation biology and geography syllabus in South

African schools. The concept was introduced for the first time in the new syllabus of 1985 and was examined for the first time in November/December 1987 (Hockey, 1995). The concept map below indicates the concepts taught under population dynamics.



Hockey (1995), in his research with 30 teachers in 19 schools from the Western Cape, found that human population dynamics as currently taught by these teachers largely emphasises the teaching and learning of facts and concepts, often out of any context to which learners can relate. He found that most teachers follow a mode of teaching that is suggestive of the above approach (i.e teacher-centred). The common use of this approach is, according to Hockey, mainly influenced by the large numbers of learners in their classes, which make teachers more comfortable to practice this mode of teaching. Most important is the fact that there has not been much emphasis placed on the teaching of population dynamics because it is the last section in the syllabus and teachers are pressed for time and skim through the content of population dynamics. Hockey suggests that there is very little time planning amongst teachers beyond timetable negotiations and exchange of ideas.

This teacher-centred and discipline-bound approach to teaching and learning creates problems because it tends to inhibit holistic thinking, critical evaluation of information and has no impact on the real lives of learners (Hockey, 1995). Such an approach is contrary to the belief that science teaching should make learning relevant to learners' daily lives and experiences (Singh, 1998). It is also contrary to the educational goals of developing intellectual autonomy in learners (Hart and Robottom, 1990). Secondly,

the teaching approaches currently practised by some teachers do not meet the requirements and demands of *Curriculum 2005.*

These problems in the way human population dynamics is taught could be alleviated using the Science-Technology-Society (STS) approach to teaching.

1.3 STS - AN ALTERNATIVE APPROACH TO TEACHING HUMAN POPULATION DYNAMICS

An alternative approach to the teaching and learning of human population dynamics is the Science-Technology-Society (STS) approach, an approach that most South African teachers are unfamiliar with and unable to use. This approach emphasises social problems, issues and events as the starting point of learning experiences and the context in which science is learnt (Hart cited by Hurd, 1989). It makes science more relevant, interesting (Hart and Robottom, 1990) and easier to understand by linking it to real situations. Learners engage in activities which deal with problems affecting their society and they analyse these problems to attempt to find solutions (Fensham, 1994). These activities allow them to develop a variety of skills (Bybee, 1986; Rubba, 1987).

The STS approach requires learners to go out into the field to study real problems, issues or events. However, it is not always possible to do so in practice because of time constraints. To overcome this problem, STS can be taught through a computer programme. Chapter two (section 2.2) discusses in detail the use and benefits of using computers in teaching and learning.

The STS approach fits well with the requirements and demands of the new curriculum (*Curriculum 2005*) introduced in South Africa.

1.4 THE DEMANDS AND REQUIREMENTS OF *CURRICULUM 2005*

On 24 March 1997, *Curriculum 2005* was launched as a new education curriculum for schooling in South Africa which makes a number of demands on teachers. Sanders, Mckenney, and Van der Laan (1999) argue that *" the new curriculum introduced by the government has placed responsibility for its success squarely on the shoulders of the teachers". Curriculum 2005* requires that Natural Science teachers who previously taught in a very traditional way make some fundamental changes in the way they teach and the way that learners are expected to learn. The government requires that teachers draw from their own experiences to facilitate the development of learner support material to ensure that it is relevant and effective (National Department of Education cited by Sanders *et al.*, 1999). Four of the basic requirements of *Curriculum 2005* are that;

- lessons are made more relevant to the learners' lives and experiences,
- learners become more actively involved in the learning process,
- learners develop a range of important skills, and
- assessment activities are used continuously to assist in the learning process (Department of Education, 2001).

Despite these demands of *Curriculum 2005*, research has shown that most teachers do not follow some of the outlined requirements because they find it difficult to understand the new curriculum, to teach accordingly and to produce their own teaching materials. Even though teachers are encouraged to design and produce their own learning programmes and learning materials, few teachers seem in a position to undertake this task. Some teachers have been found not to have time, the resources or often the skill to be involved in the development of high quality, educationally appropriate learning programmes and materials (Chisholm, 2000). As a result, some teachers feel over-burdened by what they regard as excessive and unrealistic demands that are being made on them (Chisholm, 2000).

Research has shown that teachers are struggling to implement the *Curriculum 2005*. They experience difficulties to;

- use activity-based lessons,
- use relevant lessons, and
- design their own materials and lessons **(**Khulisa, 2002).

One way to cope with some of these demands of *Curriculum 2005* is the STS approach and the use of computers to teaching.

1.5 AIM OF THE STUDY

A web-based package on human population dynamics was developed to help teachers teach human population dynamics using an STS approach. The aim of the study was to evaluate this web-based package and find ways to improve it.

This is important because designers do not adequately evaluate the programmes as they develop them (formative evaluation). Reeves (cited by Reeves and Hedberg, 2001:2) believes that *"at least part of the poor success record of instructional design is as a result of the fact that most designers have not used proper evaluation methods"*. As a result, designers have not been able to identify problems which could have been avoided by modifying the software during the developmental stages, and the quality of the resulting educational software is not optimized. Reeves and Hedberg point out that *"decisions informed by sound evaluation are better than those based on habit, ignorance, intuition, prejudice, or just best guessing"* (Reeves and Hedberg, 2001:2).

1.6 RESEARCH QUESTIONS

In order to evaluate the web-based package on population dynamics, the following two main research questions were used as a guideline:

- What are the views of natural science teachers and experts about the web-based package on an STS approach to teaching human population issues?
- How do the teachers and expert reviewers suggest the package can be improved so that it can better achieve its objectives?

1.7 IMPORTANCE OF STUDY

This study is important because it offers teachers an alternative way to teach science (human population dynamics) and at the same time provides them with useful material to use in their teaching as required in the new curriculum. According to Rogan (2000), *"Curriculum 2005"* has as one of its explicit goals the freeing of teachers from the restrictions of a rigid syllabus and the domination of the curriculum by textbooks. Even though the implementation of the new curriculum has not yet started at matriculation level, teachers are expected to develop learning programmes for their learning areas. However, teachers have experienced difficulties in developing outcomes-based packages which fulfil the requirements of *"Curriculum 2005"* (Pettitt, 2000; Sanders *et al.* 1999 and Chisholm, 2000). Because of these difficulties, and teachers' reliance on a teacher-centered approach this package is a valuable one. It will provide teachers with ideas about a learner-centered approach, which uses real-life problems in biology, and geography content (human population dynamics). It also enables learners to make links between their everyday lives and school activities.

1.8 CONCLUDING REMARKS

The next chapter explores the STS approach to teaching, theories used to design the instructional package, the benefits of using computers in teaching and the professional development of teachers.

CHAPTER TWO

THEORETICAL FRAMEWORK FOR THE DESIGN OF THE PACKAGE

INTRODUCTION

As discussed in Chapter 1, *Curriculum 2005* makes certain demands such as making lessons more relevant to the learners' lives and experiences, involving the active participation of learners in the learning process and making learners develop a range of skills. However, many teachers are finding it difficult to meet these demands because they are not familiar with alternative approaches to teaching and suitable learning theories to base their teaching on. One alternative approach to meet these demands is the Science-Technology-Society (STS) approach which most teachers are not familiar with. The STS problem approach requires that learners go out in the field to investigate problems. Because of time constraints, this approach could be taught using computers which most teachers in South African schools are not trained to use in their teaching. Therefore, this chapter explores in detail the issues of the STS approach, the importance of learning theories, the benefits of using computers in teaching and the need for professional development of teachers.

2.1 SCIENCE-TECHNOLOGY-SOCIETY (STS)

The science-technology-society approach emphasizes the use of real life situations to teach concepts. The STS approach is contrary to the traditional method of teaching which uses a teacher-centred approach and the role of the teacher becomes one which dispenses information to the learners. The STS approach includes the learners in the teaching and learning processes, therefore they become active participants in acquiring the knowledge. The involvement of learners in their learning process easily meets one of the demands of *Curriculum 2005* which requires learners to become more actively involved in the learning process.

Yager and Tamir (1993) state that STS is defined as teaching and learning science in the context of human experiences. STS focuses on the applications and use of knowledge which is relevant to the life of the individual and to society, and the central role of the teacher in curriculum development. Yager, Tamir and Huang (1992) have defined STS more broadly to include goals, curriculum, assessment, instruction strategies and teacher preparation/performance. The STS approach examines the interface between science, technology and the social world (Trowbridge and Bybee, 1990 and Hughes, 2000). The National Science Teachers Association (NSTA) defines STS as the latest effort to provide a real world context for the study of science and for the pursuit of science itself (Ajeyalemi, 1992). STS focuses upon

current issues and attempts at their resolution by identifying problems, planning activities to address them and moving to actions designed to resolve the issues investigated. STS means focussing on real-world problems instead of starting with concepts and processes which teachers and curriculum developers argue in terms of usefulness to learners. In teaching the content from the learners' real-life experiences also meets one of the demands of *Curriculum 2005* which requires that lessons are made more relevant to the learners' lives and experiences.

2.1.1 What is STS science teaching?

According to Aikenhead (1994a) STS teaching is learner oriented, as contrasted with the scientist orientation of traditional science teaching. The learner-oriented character of STS science teaching is where learners strive to understand their everyday experiences. Learners do so by making sense out of their social environment and their natural environment. The STS approach starts with what the teacher or learner thinks is important, with the learners' interests, and with what is relevant to their lives.

According to Aikenhead (1994b) and Solomon and Aikenhead (1994), STS science instruction demands a wide repertoire of teaching strategies such as divergent thinking, small group work, learner-centered class discussion, problem solving, simulations, decision making, controversies, debating, and using media and other community resources. Traditional science teaching methods on the other hand tend to be characterized by convergent thinking and lecture-demonstrations.

The content of the STS approach arises from human experience, either brought by learners to the classroom or through situations stimulated by the teacher. Yager and Tamir (1993: 37) identify five goals for the STS approach which are characterized as domains and includes the following:

- *Concept domain* - includes the facts, information, concepts, laws, principles, existing explanations, and theories being used by scientists.
- *Process domain* - being able to use the processes of exploring and investigation in a wide variety of situations. STS advocates personal use of skills acquired in new situations.
- *Application domain* - inclusion of information, skills, and attitudes that can be transferred and used in learners' everyday lives. For example, seeing instances of scientific concepts in everyday life experiences; applying concepts and skills to everyday problems; using scientific processes in solving problems that occur in everyday life; making decisions related to personal health, nutrition, and life style based on knowledge of scientific concepts rather than on hearsay or emotions; taking specific actions designed to resolve problems and/or contribute to the improvement of local, regional, national, and/or international problems and extending school experiences beyond the classroom. This means making the materials in a science course related to real-life situations.
- *Creativity domain* - encourages the development of creative abilities such as visualizing or producing mental images; solving problems and puzzles; predicting possible consequences; suggesting possible causes etc.
- *Attitude domain* - includes developing positive attitudes toward science in general, science in school and the science teacher; developing positive attitudes towards oneself; making decisions about personal values; making decisions about social environmental issues; and exploring arguments on various sides of an issue. This is important because learning is enhanced when learners have positive attitudes about the subject.

2.1.2 Methods of teaching STS

It is important that science should not be seen as an abstracted field of study concerned entirely with the concepts of science, but rather should be linked with both technology and society. Ramsey (1993) claims that "scientific knowledge is not de-emphasized, it is obtained and used on a need-to-know basis". His belief is that, as real life problems are investigated, learners search for scientific and technical information that can be applied to solve these problems.

This approach meets some of the learning outcomes for Natural Sciences such as;

- Scientific investigation: to investigate relationships and solve problems in scientific technological and environmental contexts.
- Constructing science: to interpret and apply scientific, technological and environmental knowledge
- Science, society and the environment: to demonstrate an understanding of the inter-relationship between science and technology, society and the environment (Department of Education, 2002).

Science educators have different views about what constitutes an STS programme. Some authors claim that STS is not a replacement for conceptual science but an essential supplement to it. (Lynch, Murtough and Nusirjan 2000 and Hughes, 2000). Thus, STS can either be taught alongside science or integrated into science courses. Hughes (2000) however, says that STS may also be viewed as part of the curriculum in its own right. It can be viewed as merely a vehicle for delivery of conceptual science content or the STS context may be included as a worthwhile subject for study along-side the concepts. Solomon (cited by Fensham, 1993) criticises these views because they do not reposition science into a social, economic, political, and moral context as only a brief social context is fused into science curricula. They normally add on a brief social context within rigidly prescribed science content in restricted topic areas. Aikenhead (1994a) has categorized different approaches to STS science teaching into 8 groups as shown in the table below.

Table 1: Categories of STS science based on Aikenhead (1994:45)

CATEGORY	DESCRIPTION OF TEACHING APPROACH
Motivation by STS content	Traditional school science, plus a mention of STS content in order to make a lesson more interesting. Learners are not assessed on the STS content.
Casual infusion of STS content	Traditional school science, plus a short study of STS content attached onto the science topic. Learners are assessed mostly on pure science content and usually only superficially on the STS content.
Purposeful infusion of STS content	Traditional school science, plus a series of short studies of STS content integrated into science topics, in order to systematically explore the STS content. Learners are assessed to some degree on their understanding of the STS content.
Singular discipline through STS content	STS content serves as an organizer for the science content and its sequence. The science content is selected from one science discipline. Learners are assessed on their understanding of the STS content.
Science through STS content	STS content serves as an organizer for the science content and its sequence. The science content is multidisciplinary, as dictated by the STS

	content. A listing of pure science topics looks like a selection of important science topics from a variety of traditional school science courses. Learners are assessed on their understanding of the STS content, but not as extensively as they are on the pure science content.
Science along with STS content	STS content is the focus of instruction. Relevant science content enriches this learning. Learners are assessed about equally on the STS and pure science content.
Infusion of science into STS content	STS content is the focus of instruction. Relevant science content is mentioned, but not systematically taught. Emphasis may be given to broad scientific principles. Learners are primarily assessed on the STS content, and only partially on pure science content.
STS content	A major technology or social issue is studied. Science content is mentioned but only to indicate an existing link to science. Learners are not assessed on pure science content to any appreciable degree.

This study infuses the STS content to teach the school science so that it could make learning interesting and motivating to the learners as well as applicable in their real-life situations. Assessment of the learners was continuously done through various activities on science content without much depth on the STS content.

2.1.3 Science-related problems

In this research, the STS approach used was based on problems. Ramsey (1993) suggested that a science-related social problem is one that has its roots in science and/or technology. It involves a problem surrounding which there are different beliefs and values. Therefore, within population dynamics, issues such as those involving human population decrease (mortality and emigration) and population increase (natality and immigration) for instance can be studied.

It is believed that the science-related problem provides the greatest potential for understanding science in a context of its political, economic, social and ethical implications (Ramsey, 1993). Furthermore, it provides learners with many opportunities for information processing, problem solving and decision making in science. Skills are learnt and applied to other science-related problems. Dealing with such problems involves activities and investigations, discussions and debates, where learners learn to understand scientific evidence and its limitations, assess risks and benefits, ask questions, and make decisions based on evidence rather than on pure emotion.

The teacher can approach problem solving in a wide variety of ways by creating situations where understanding of concepts can grow, where issues can be explored, and where learners can interact. The teacher may pose or ask open-ended questions, provide and make available a variety of materials for the solution of a problem and connect the lesson to learners' interests (Casey and Tucker,1994). In such instruction, the teacher shifts the role of being the dispenser of information to a provider of resources that would enable learners to acquire knowledge on their own.

2.1.4 Reforms in science education

In 1996, South Africa embarked on curriculum reforms which were to be implemented throughout the education sector in the country. This curriculum change was aimed at implementing a learner-centred outcomes approach to education (Graven, 2001). Some of the key principles on which the curriculum is based are relevance, participation and ownership, learner-centred learning, and critical and creative thinking (Graven, 2001). It was suggested that teaching would improve the quality of science education in the country by becoming more learner-focussed, relevant to the learners' lives and based on the development of relevant skills (Sanders, 1999).

According to Solomon and Aikenhead (1994) many science educators elsewhere are proposing a major science curriculum reform to prepare learners to understand the roles of science and technology in their personal lives. For this reason, STS is becoming important because the STS approach presents concepts in a context that is centred on the needs and interests of the learner, and can provide an experience-based understanding of the impact and importance of modern science and technology. Currently, science education presents science in the abstract, which is neither motivating nor inclusive of the majority of learners (Hughes, 2000), resulting in poor learner achievement, lack of participation in science courses, low standards, and inadequate requirements (Trowbridge and Bybee, 1990). Trowbridge and Bybee (1990) argue that science courses in general have not been directed toward personal or societal problems involving science and technology. They feel that science education must be taught in a way to bridge the gap between the search for knowledge and its utilization.

Even with these reforms, in many American and African countries science curricula are based on text books that present science as a body of information, a mass of disconnected facts and generalizations that required rote memorization (Hurd *et al.,* 1980, Rosenthal, 1985 and Ajeyalemi, 1992). Science education all along has been deemed to be out of touch with society, leaving learners poorly equipped to deal with a complex modern world of scientific and technological controversy (Fensham, 1993).

Many countries base their science education on goals that tend to emphasize academic preparation to the exclusion of personal, societal, and career goals (Harms cited by Harms and Yager, 1990). These curricula teach science that is not grounded in action, socially constructed, culturally relevant and providing a context of action. This is as a result of regarding and seeing scientific knowledge as separate from educational and social connections which is not the case (Jenkins, 1994). Such science does not considers learners as being participants in the teaching process (Watts *et al*., 1997) which permits learners to engage with issues or problems, allowing them to make decisions and suggesting practical actions. Such a science has local applications and is rich in values. The table below outlines some of the major differences that exist between STS and traditional instruction.

Table 2: Distinguishing characteristics of STS and traditional instruction (Yager, Tamir and Lellerman, 1994).

STS INSTRUCTION	TRADITIONAL INSTRUCTION
Learner-centered	Teacher-centered
Directed by learner questions and experiences	Directed by the textbook
Uses a variety of resources'	Uses basic textbooks
Teachers build on experiences	Teachers build on organized, easy-to-grasp information
Teachers plan teaching around problems and issues	Teachers plan from the prescribed curriculum guide and textbook
Learners considered active contributors to instruction	Learners recipients of instruction

2.1.5 Benefits of using an STS approach

Learners in the STS approach engage in science that emphasizes both scientific processes and the nature of inquiry (Pederson, Bowyer, Butts and Bybee, 1984). It is an approach that places learners in a central position of acquiring knowledge which promotes learning (Yager *et al*., 1992). This appoach also meets some of the learning outcomes mentioned in section 2.1.3.

STS integrates the interaction between science, technology and society (Solomon, 1993) and allows learners to use relevant issues around them (Costa, 1995). There have been a number of positive effects with the usage of the STS approach in teaching and learning such as;

- STS improves both learner interest and enjoyment of science (Aikenhead, 1994).
- Yager *et al.* (1992) in a study of 116 freshmen and sophomore nonscience majors enrolled in Taiwan in a Human Biology course using the test-retest reliability (0.80) found out that there was an enhancement of the mastery of basic concepts. This was a result of greater learner motivation because the organization of the course was more relevant (i.e. related to personal and social issues). There were also improvements in attitudes towards biology, learner understanding, use of science process skills and the ability of learners to use biology concepts. In addition, improvements were seen in creativity with questioning and the suggestion of causes as well as consequences of societal problems. However, Watts, Alsop and Zylbersztajn (1997) found no difference in learners' conceptual understanding and academic achievement.

Harding and Sutoris (1987), Sjoberg and Imsen (1988) and Fensham (1993) believe that the inclusion of STS is especially important for the motivation and retention of girls. Several educators claim that the personal aspects of STS, and also how it is taught are more suited to the way in which girls like to learn about science than is the traditional method of teacher-centeredness (Kahle in Yager *et al.* 1992 and

Hughes, 2000). It is also becoming more accepted that an STS curriculum can increase learner engagement with science, and thus has the potential to improve inclusivity (Hughes, 2000). Attempts to socialize school science have aimed to enhance learners' powers of decision-making and problem solving and have offered a balanced view of the very nature of scientific and technological knowledge (Watts *et al.*, 1997).

According to a research program that dealt with the impact of STS instruction on learners in grades 4 to 9 taught by teachers who had done an STS workshop (Yager *et al.*, 1994), learners in STS classes benefit more than those in traditional science classes in the following:

- Improving understanding of the social issues both internal and external to science, and to the interaction among science, technology, and society.
- Becoming more capable at applying science concepts to new situations.
- Applying information, to relate information to other situations, to act independently, and to make decisions.
- Improving attitudes towards learning science.
- Improving in science process skills achievement.
- Making modest gains in thinking skills such as applying science content to everyday situations, critical and creative thinking, and decision-making.

Mayer (1997) argued that the acquisition of traditional science content was significantly better for STS learners. He further states that STS efforts may be effective where traditional approaches fail because learners start with their own problems, collect data, apply to their problems, and make decisions. In an STS approach, learners learn beyond the ideas from activities in textbooks (Yager *et al.,* cited by Yager and Tamir, 1993).

2.1.6 The effects of contextualising science teaching

Peacock (1991) emphasizes that contextualising the science teaching improves access resulting in equity for disadvantaged groups and it improves learners' motivation to engage in learning (Yager and Tamir, 1993). However, the most important reason for contextualising science teaching is because it provides the aspects of applicability and usefulness (Campbell *et al.,* cited by Hughes, 2000). It is argued that learners who have been taught a contextualised science course often use science ideas to solve science-based everyday problems or to explain everyday situations (Dlamini, 1999).

Teaching STS demands a lot of time for learners to go out in the field to collect information. But this could be minimised through the use of computers which have advantages such as the ones discussed below.

2.2 THE BENEFITS OF USING COMPUTERS IN EDUCATION

This section looks at the benefits of using computers in science education. It has been increasing advocated that the use of computers can solve educational problems, for instance Topper (2000:1) argues that *"some people are claiming that the Internet will fundamentally change education at all levels"*. However, it is important to first find out to what extent and in what ways computers can improve teaching and learning.

2.2.1 Arguments for the use of computers in education

Recently, there has been an emphasis on the use of computers in South African schools. The structure of the new curriculum and the Department of Education demand that teachers should use computers when teaching. According to Sanders (2001: 1) *" the use of computers in education has been proposed as one way of addressing the crisis in mathematics and science education in the country."* The *Curriculum 2005* strongly highlights the necessity for schools to teach information technology i.e word-processing, spreadsheets, Internet search etc (Pretorius cited by Sanders, 2001). However, teachers will need a lot of support and help in terms of skills and competencies in order to undertake such a huge task. Teachers first need to know and understand some of the uses of computers in improving teaching and learning. Secondly, teachers need to understand theories that affect teaching and learning. Below is a table showing what teachers and learners do with computers and the advantages of doing tasks with computers rather than off-line.

Even though not all these uses were applied to this research, as a designer of instructional material it was important to find out what computers could generally be used for in teaching and learning, then draw out the advantages or benefits. It is important to realize that it would be wasteful in terms of time and resources to simply develop a package that does not consider the merits of using computers in teaching because it might even be better to present the same material in another medium like notes or a book.

Table 3: Uses and advantages of using computers.

USES OF COMPUTER		**ADVANTAGES OF USING THE COMPUTER**
1. Preparation		
word - processing	1. Creating and writing materials such as assignments, notes and notes (Stephen, 2001).	• Save time to re-write scripts due to mistakes, thereby reducing the workload and in the process improving writing skills.

2. Record keeping & management		
spreadsheets	1. Calculating statistical data in tables (De Klerk, 1994; Pogge and Lunetta, 1987). 2. Visually display of data in graphs and charts (Nicol, 1990; Carter, 1999).	• Calculates data automatically and quickly because of the in-built calculator software rather than using a manual calculate. • Learners can change the values for the programmed equations in the table and see the visual effect on the graph or chart (Nicol, 1990; Carter, 1999). Computers are the best medium for dynamic processes requiring understanding of relationships between moving objects.
Database	1. Accessing data that has been stored on the database. 2. Updating stored data	• Easy accessibility of stored data by a click of a mouse as compared to finding data in files which takes time to find and tedious. • Easy to update data by deleting un-necessary data and typing in the new information as compared to re-writing the old and new data in files again.
3. Electronic communication		
e-mail	1) Sending mail between learners and teachers of the same school, teachers and learners of the same school or outside, teachers and parents. 2) Asking questions and getting responses from teachers, parents or learners.	• It is convenient and quicker to send mail in seconds rather than using the letters which take long. • Gives quick/immediate response assuming that the computer is working well without any interruptions and the receiver is available at that particular time to respond. • It is convenient to send queries through e-mail whilst working on tasks without closing the programme.
Information source		
1 . multimedia 2. Internet 3. libraries	1. Easy accessibility of huge information from other libraries, schools, databases etc. 2. Provision of largest data resource and can easily access many libraries on-line.	• Quicker to retrieve information on the Internet than travelling to these places to obtain information, which is costly and time constraining (Crovello, 1982).
As a source of teaching material		
Graphics	1. Drawing and painting. 2. Manipulation of images. 3. Provision of images in 3-D or microscopic nature.	• Allows for experiences otherwise not possible in a normal teaching classroom such as elucidating parts of a difficult process in more detail (microscopic items, nuclear power station, photosynthesis, cellular respiration etc.). • Allow to present material that is in 3-D which is difficult to visualize with traditional AV aids like textbooks and those that are difficult to visualize.

Instruction		
Tool	1. Tutoring	• Allow learners to work and to proceed at their pace unlike the teacher who rushes to cover the tasks because of time constraints. Computers have longer office hours than teachers and rarely get grumpy (Stephen, 2001; Crovello, 1982; Matray and Proulx, 1995). • Allow learners who are slow in finishing their work to take their time because they can always go back to work at their own time and pace. The teacher can never repeat a lesson twice because the teacher is often impatient, biased and ratty. • Computer software are patient to repeat a task at any time than the teacher because they never get tired of repetitive tasks. • Well-designed computer programmes allow for self-paced learning in a non-threatening environment and are nonjudgmental (Matray and Proulx, 1995). This is essential for learners who have low self-esteem and who tend to lack confidence (Sanders and Ayayee, 1997, and Crovello, 1982). • Offers learners tasks that are accessible and always available making it flexible than a teacher who can only be available at specific times (Draper, 1998). • Using computers allow learners to get actively engaged mentally even though they are just reading, in contrast to whole class teaching where some learners may not be listening to what teachers are saying. • Individual feedback which is instant can be given to learners on specific problems.
	1. Simulation	• Can provide simulations for experiments that are expensive, complex or dangerous to use in the laboratories (Crovello, 1982 and Draper, 1998). • Provide simulations of real world events which are closely based on real world simulations providing experiences which may not be possible (Mandell and Mandell, 1989). For instance, it would be difficult and unacceptable for learners to perform surgery on a human body.
Oral presentation		
slide shows e.g Power point/Corel presentation	1. Presentations of lessons and projects	• Introduce features with movement unlike transparencies which are stationed. • Allow smooth discussion by introducing one point at a time over transparencies which display all points at a time. • Helps maintain the attention and focus of the audience by discussing one point at the time rather than glancing through other undiscussed points on transparencies that have not been introduced.

2.2.2 Arguments for the benefits of using computers

Apart from the general uses of computers, there are several advantages that teachers can derive from using them in their teaching. Benefits of using computers in this research included the following;

• *Computers if well-designed mentally engage learners in tasks*

The time spent working on the computer is more efficient because learners are actively engaged in their learning, even if it is just reading (Sanders, Mckenney and Van der Laan, 1999, and Sanders and Linkonyane, 2001). This is better but still needs caution. In the package developed, teachers would offer their learners an opportunity to not only master the science content required but also develop in learners a number of skills which could not be possible in a normal teaching session. For instance, the learners may be motivated to do activities using the computers as compared to writing, access information on the Internet etc.

• *Computers are patient*

Computer aided instruction is infinitely patient, allowing learners repeated trials (Mayer, 1997) A computer is never biassed and ratty like the teacher (Sanders and Linkonyane, 2001). Unlike the teacher who has limited time for a session, the use of computers would let the learners repeat activities on their own without the presence of their teachers.

• *Computers allow for experiences otherwise not possible*

Computers can present materials which are difficult, complex, abstract and/or microscopic processes to visualize with traditional visual aids (Sanders and Linkonyane, 2001, and Phillips, 1997). Computers also elucidate parts of a difficult process in more detail such as microscopic items, cellular respiration etc (Draper, 1998 and Stephen, 2001). The use of simulations allow learners to visualize the processes and be able to understand as well as to explain such difficult processes. In traditional teaching, it is hard to visualize complex processes using technology such as whiteboard or overhead transparencies which are two-dimensional and static (Phillips, 1997). He also claims that the use of simulations can be made available for learners in a self-paced manner for use as reinforcement tools. The use of a spreadsheet in the computer package developed provided an easy way to present the increase and decrease of population that would let learners easily visualize the trends than traditional visual aids like transparencies.

• *Computers allows the transmission of different medium*

Computers can present a variety of messages within one lesson such as animation for processes and graphics for spatial interpretation. According to Phillips (1997) *"this offers clear advantages in some teaching situations over mono-media resources, such as whiteboards and audio cassettes".* He claims a particular advantage is the possibility of using the most appropriate mediumm for the required message like text for thought, graphics for spatial relations and animation for dynamic information. Some graphics were used in the package to make a connection between the text and the topic (Sanders and Linkonyane, 2001).

Other benefits of using computers that may have not necessarily been applied in this research included;

• *Computers provide simulation*s *and visualization*

Computers if well-designed can permit experiments which are expensive, complex or dangerous to be carried out (Crovello, 1982 and Draper, 1998).

• *Computers allows learners to control their learning*

According to Phillips (1997) most instructional materials haas the ability to allow users to take their own path through the material and therefore, computers allow learners to work and proceed at their own pace (Crovello, 1982; Matray and Proulx, 1995 and Stephen, 2001). This is important because the users will be able to build up their own knowledge promoting a learner-centred approach to learning.

• *Computers are always accessible*

Computers are often accessible and available at any time for learners to work on their tasks (Draper, 1998).

• *Computers provide safe working environments*

Computers provides learning in a non-threatening environment and are nonjudgmental (Matray and Proulx, 1995).

• *Computers give individual feedback*

Computers can be designed to give an individual learner feedback on specific problems, unlike a teacher who cannot attend to many learners at a time (Sanders and Linkonyane, 2001).

Even though teachers and learners can use computers for the above purposes, it is important to point out that it is not the use of computers as such which will improve education. Effective teaching will occur only with well-designed educational software which is used effectively. However, caution has to be noted that computer software cannot replace the teacher nor can it improve the teaching ability of a weak teacher. Rather computer software can allow a conscientious and creative teacher to present material in more interesting and effective ways (Matray and Proulx, 1995). Secondly, it is not any computer software that can improve learning, but if well-designed and properly used by teachers, effective teaching and learning can take place.

2.2.3 Research findings on learning in the sciences using computers

The uses and benefits of computers mentioned in 2.2.1 (tables 3) are based on logic and theoretical arguments. But does research find that using them does in fact make a difference to teaching and learning? It is important to find out what research says about effective teaching and learning because important lessons can be learned from personal knowledge derived from participation in or observation of others regarding good educational practices. It is these lessons which instructional designers of software can adopt and transfer into their design in order to improve teaching and learning. Sanders and Mckenney (1998) claims that teachers who are aware of research findings on effective teaching and learning are more likely to make successful choices in their classroom practices than those who are unaware of them, and the same holds true for instructional designers.

Below are some examples from research findings on uses of computers in science education.

• *Using computers often improves learner' attitudes to learning.*

In the study that Jegede, Okebukola and Ajewole(1991) carried out with 64 learners in Nigerian Joint Matriculation Examination in biology, they found that computers significantly changed learners' attitudes resulting in significantly higher course averages and improved performance. The group of learners who interactively used the computer had a more favorable attitude toward the use of computers in learning biological concepts than learners who had no such opportunity.

• *Using word-processors can improve learner's writing skills*.

Wainwright (1989) carried out research with 100 learners in Minnesota (USA), where he evaluated the attributes of a microcomputer software package. The results showed that computer software can be designed to correct errors such as improper subscripts, and spelling errors. The computer software can

prompt following the second error in order to obtain a correct answer and to let the user proceed. In this study, the use of the microcomputer material by an experimental group clearly showed that it contributed to effective learning of the subject area.

- *Learners using computers for educational purposes are often more actively engaged in the learning process.*

The study conducted by Schoefield, Evans-Rhde and Huber (1989) on the implementation of a mathematical package, *Geometry Tutor,* in a public high school showed that teachers were spending more time with learners having problems. In this study, the learners were more involved in carrying out academic tasks. This package was believed to have altered the role of educators in the study from that of a transmitter of knowledge to a guide and/or resource person. However, Schoefield *et al.* caution those designing computer materials to choose topics/concepts which are to be taught very carefully because not all topics can be effectively taught using computers.

Even if there are many benefits of using computers in teaching that one can be aware of, it is not enough to ignore other factors that affect effective learning. It is important to be aware of other instructional strategies that can be expected to facilitate learning, such as theories of learning.

2.3 THEORIES OF LEARNING

2.3.1 Why consider learning theories?

Many designers do not design their programmes on sound educational principles. Leshin *et al.*, (1992 cited by Reeves and Hedberg, 2001:23) argue that *the major problem with existing instructional materials is that the designers of instructional materials have totally ignored guidance as to what makes good instruction*. Reeves and Hedberg (2001:4) also claim that in many cases, *educational software tools such as word-processing, spreadsheet, and database programs have failed to improve teaching and learning significantly because they have not been integrated with an appropriate instructional design*. Most instructional designers have not seriously considered the advice on good design which are important for success in effective instructional materials. According to Hannafin (1992:45) *"prospective computer assistance instruction developers have been led to believe that developing CAI requires little knowledge. This is a dangerous misconception, one that has contributed to the glut of substandard software presently available"*. Materials designed by such people are unlikely to be good quality instructional materials.

According to Ausubel, Novak and Hanesian, (1978: 15)*" learning theories offer us the most feasible point of departure for discovering general principles of teaching that can be formulated in terms of cause-effect relationships"*. It is from theories of learning that one can have the ability to develop notions of how crucial factors in the learning-teaching situation can most effectively be handled.

The purpose of looking at these theories are;

- to be familiar with and to understand the processes of teaching and learning,
- to know the advantages of using these theories so as to make right choices on which teaching methods could contribute to effective teaching and learning,
- to form a basis on which to build teaching strategies which allows for professional decisions that are likely to make more effective teachers (Sanders, 1988).

Below are some detailed explanations on each learning theory that were considered in the design of the computer package.

2.3.2 What is situated cognition?

The focus of situated cognition is on relevance and transfer of information learnt in a specific situation to different situations in life (Anderson, Reder and Simon, 1997 and Watson, 1998) and its importance of learning within the context of real-world applications (Herrington and Oliver, 1997). This is different to the traditional method of teaching and learning where much of the knowledge taught in schools is not retrievable in real-life and does not involve real-life problem-solving contexts, because the traditional approach ignores the interdependence of situation and cognition (Herrigton and Oliver, 2000). Herrigton and Oliver contend that when learning and context are separated, knowledge itself is seen by learners as an end product of education rather than as knowledge to be used to solve problems in real life. However, they argue that it is not suggested that formal instruction should be abandoned in favour of the situated cognition approach. Rather, it is important to determine the pedagogical significance of the findings from situated learning which could promote appropriate and effective classroom techniques and practices in promoting meaningful learning. This could be achieved if the theory of situated cognition is researched and developed for practical classroom applications.

The theory of situated learning describes the way in which learning is linked to the situation or context in which it takes place (Lave cited by Boaler, 1998). Situated learning occurs when learners work on authentic tasks that take place in real-world setting (Harley, 1993 and Jonassen, 1994), whereby learning becomes a function of the activity, context and culture in which it occurs (Lave and Wenger, 1991, McLellan, 1996 and Lave, 2002). Secondly, situated learning focuses on the connection between school situations and real world situations (Wofson and Willinsky, 1998) where one needs to use the knowledge learned. There has to be a relationship between what is learned in the classroom and what is needed outside of the classroom (Watson, 1998). That is why learning theorists who support the ideas of situated cognition suggest that learning must be set in contexts which have meaning for the learners so that they can understand new concepts and establish ideas by using real life examples. In doing so, learning of concepts is claimed to improve if the learning is situated in a context, which is meaningful to the learners (for more detail see table 4 on page 28).

2.3.3 Research findings on situated learning

Research findings are equally important as theories of learning because one is able to learn from the experiences of others on effective classroom teaching, thereby avoiding making or repeating the same mistakes that others have made.

Boaler conducted ethnographic, three year qualitative case studies (Eisenhart, 1988) in two schools in the United States of America, where she wanted to monitor the relationships between the learners' day-to-day experiences in classrooms and their developing understanding of mathematics. She found that at one school where booklets and textbooks were used for teaching, the learners developed an inert, procedural knowledge that was of limited use to them. They could not use the knowledge in any other situation than the textbook. On the other hand, the school that encouraged learners to take responsibility for their own action and to be independent thinkers had lessons with a relaxed atmosphere and allowed learners to work on open-ended projects acquired some learning that was usable. According to Gibson (cited by Boaler, 1998), the learners at this second school were able to use the knowledge acquired in their instruction because of the willingness and ability to perceive and interpret different situations and develop meaning from them. Further, they could relate to the knowledge acquired, had sufficient understanding of the procedures and had confidence that enabled the learners to adapt and change procedures to fit new situations. According to Boaler (1998), the study showed some indications that the traditional way of teaching was ineffective in preparing learners for the demands of the real world and was no more effective than a process-based approach for preparing learners for traditional assessments of content knowledge. She concludes that a traditional textbook approach that emphasises rules and procedures, at the expense of depth of understanding, is disadvantageous to learners because it encourages learning that is inflexible, school-bound, and of limited use.

2.3.4 The situation of the teacher in situated learning

The link between the classroom and the real world viewed in situated learning means that the teacher is no longer regarded as the only expert of knowledge in the classroom situation. The teachers' role changes from that of depositor of knowledge to that of a facilitator and guide (Watson, 1998; Wofson and Willinsky, 1998, and Cobb and Bowers, 1999). The teacher forms part of a team of mentors and guides for learners, and is as much a facilitator of the situation of learning, able as such to draw on the experience of the mentors in arriving at an assessment of the learning that has taken place in the learner (Watson, 1998 and Anderson, Reder and Simon, 1996 and 1997). Most of the time, the teacher spends time helping groups and individuals meet the demands of their tasks. In this teaching approach, the teacher does not become the centre of the teaching process, but rather involves the learners as well in the activities.

2.3.5 Constructivism

As much as it is important to situate the content with what learners already know, making sure that learners have constructed what they are learning is also crucial in effective teaching and learning. According to Jaworski (1994: 14) *"constructivism is a philosophical perspective on knowledge and learning"*. Constructivism is concerned with the process of how learners construct meaning and knowledge in the world as well as with the results of the constructive process (Reeves and Hedberg, 2001). Constructivism views knowledge not to be about the world, but rather as a constitutive of the world. This entails that knowledge is not a fixed object, but it is constructed by an individual through her own experience of that object. As a result, constructivist theory of learning acknowledges that individuals are active agents who engage in their own knowledge construction by integrating new information into their schema, and by associating and representing it into a meaningful way (Driscoll, 2000a).

But while it is important for educators to understand constructivism, it is equally important to understand the implications this view of learning has for teaching and teacher professional development. It is argued that how learners construct knowledge depends upon what they already know, their previous experiences, how they have organised those experiences into knowledge structures and the beliefs they use to interpret the objects and events in the world (Reeves and Hedberg, 2001). Learners learn situations with knowledge gained from previous experience, and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences. Secondly, learning is an active process rather than passive. Learners confront their understanding in light of what they encounter in the new learning situation. If what learners encounter is inconsistent with their current understanding, their understanding can change to accommodate new experience. Learners remain active throughout this process: they apply current understandings, note relevant elements in new learning experiences, judge the consistency of prior and emerging knowledge, and based on that judgment, they can modify knowledge (Driscoll, 2000a).

Therefore, constructivism's central idea is that human learning is constructed and that learners build new knowledge upon the foundation of previous learning. This view of learning sharply contrasts with the traditional approach in which learning is based on passive transmission of information from the teacher to the learner, a view in which reception, not construction, is a major key (Kelly, cited by Cohen and Manion, 1994, Jaworski, 1994 and Driscoll, 2000b). The constructivist approach proposes that individuals construct knowledge by modifying their experiences. In the process of construction, individuals build their own meaning and ideas in a way that these fit with real-world experiences and surroundings. In so doing, learners need to construct explanations which fit the situation they have encountered, emphasising the way learners come to know rather than about the knowledge being learned.

Constructivism has important implications for teaching. According to the constructivist theorists (Lave, 1991; Anderson *et al.*, 1997; Watson, 1998; Boaler, 1998 and Driscoll, 2000a).

- teaching cannot be viewed as the transmission of knowledge from enlightened (teacher) to unenlightened (learner). The teacher does not make all the decisions and dump the information on learners, rather learners are involved in the process of learning. The teacher gives guided instructions that puts learners at the centre of learning process by providing guidance and teaching whenever necessary.
- since learning is based on prior knowledge, the teacher notes that knowledge and provide learning environments that exploit inconsistencies between learners' current understandings and the new experiences before them.
- since learners must apply their current understandings in new situations in order to build new knowledge, teachers must engage learners in learning, bringing learners' current understandings to the forefront. Teachers can also encourage group interaction, where the interplay among participants helps individual students become explicit about their own understanding by comparing it to that of their peers.
- since learning is an active and a constructive process, instruction must be designed to provide opportunities for such construction. (See table 4 for more details)

2.3.6 Meaningful learning

Thirdly, it is important to note that learners are not blank slates and therefore, learning must be meaningful to the learners. Learners participate in tasks with performed cognitive structures. During learning, they expand and revise these structures based upon the new experiences to which they are exposed (Heinze-Fry, Crvello and Novak, 1984). The most important factor that influence meaningful learning is what the learner already knows.

Therefore, Meaningful learning *"takes place if the learning task can be related in a nonarbitrary, substantive (nonverbatim) fashion to what the learner already knows, and if the learner adopts a corresponding learning set to do so*" (Ausubel *et al.*, 1978: 27). It means that learning will only be meaningful if the new idea or concept to be learned is consciously related the relevant concepts which the learner already knows (Ausubel, 1963). In order for learners to acquire meaning in their learning, there should be potentially meaningful material and meaningful learning environments.

Table 4 summarises how learning takes place and what kind of activities a teacher needs to use when using situated learning approach to teaching.

SITUATED LEARNING	
Definition	• Emphasis the importance of learning within the context of real-world applications (Herrington and Oliver (1997) and Lave (2002). • Is the learning of skills in contexts that reflect the way the knowledge will be useful in real life (Collins, 1988; Anderson *et al.*, 1996 and Herrington and Oliver, 2000).
Instructions	• Instruction for the acquisition of knowledge needs to be presented and learned in an authentic context, i.e. settings and applications that would normally involve that knowledge (Lave, 1991) . • Direct instruction towards social interaction and collaboration (Lave and Rodoff cited by Cobb and Bowers, 1999).
How learning takes place	• Learning occurs as a function of the activity, context and culture in which it occurs, it is situated (Lave, 1991; McLellan, 1996; Collin cited by Herrington and Oliver, 2000; and Anderson *et al.,*, 1996). • Knowledge is constructed through interacting between learners, learning activities and situations (Driscoll, 2000b and Lave, 2002).
Types of activities necessary for learning.	• Provide activities which have real-world relevance (Herrington and Oliver, 2000). • Provide ill-defined activities (Herrington and Oliver, 2000). • Provide activities that require social interaction (Lave, 2002).
CONSTRUCTIVISM	
Definition	• *Knowledge neither come performed in the genes nor in the environment, but is actively constructed by the developing individual* (Saxe, 1991: 13). • Learners actively construct knowledge for themselves by inventing their ideas as each learner individually and socially construct meaning as he or she learns (Jaworski, 1994 and Driscoll, 2000a).
Instructions	• Instruction must be concerned with the experiences and contexts that make the learner willing and able to learn (readiness). • Instruction must be structured so that it can be easily grasped by the learner • Instruction should be designed to fill in the gaps by going beyond the information given (Bruner, 1985). • Instruction should be directed to encourage learners to discover principles by themselves. Learners should engage in active learning.
How learning takes place	• Learning is as a result of mental construction which involves problem solving, reasoning, critical thinking, and the active and reflective use of knowledge (Driscoll, 2000b). • Learners learn by fitting new information together with what they already know and when they actively construct their own understanding. • Learning is an active process in which the learners construct new ideas or concepts based upon their current or past knowledge (Bruner, 1985). • Learning is not the passive acceptance of knowledge which exists out there but learning involves the learners engaging with the world.
Types of activities necessary for learning	• Activities that engage the mind (mental) • Activities that require physical actions, hand-on experience • Activities that engage learners in talks, discussions etc. • Activities that involve multiple representations of reality that reflect the real world complexity ((Jonassen, 1994). • Activities that requires the process of knowledge construction (Jonassen, 1994). • Activities that provide real-world settings and provide reflection on experience (Chen, 2001).
MEANINGFUL LEARNING	
Definition	• *Meaningful learning involves the acquisition of new meanings, and new meanings, conversely, are the products of meaningful learning* (Ausubel *et al.*, 1978: 41). • Learning will only be meaningful if the new idea or concept to be learned has personal relevance to the learner he/she already knows (Ausubel, 1963 and Sanders, 1999).

Instructions	• Instruction for meaningful learning should link with the real-word knowledge of learners (Sanders, 1999).
How learning takes place	• Learning happens when the material has a particular pattern or purpose and is related to the corresponding relevant ideas (Ausubel *et al.,* 1978).
Types of activities necessary for learning	• Activities that has relevancy to the learners. • Activities that require the application of what learners already knows.

2.4 PROFESSIONAL DEVELOPMENT OF TEACHERS TO MEET *CURRICULUM 2005* REQUIREMENTS

The new curriculum demands that teachers meet the requirements and demands discussed in 1.4. However, teachers have experienced difficulties in making these changes. According to Chisholm (2000) the implementation of *Curriculum 2005* has been hampered by;

- the complex structure and design of the curriculum,
- the inadequate quantity and poor quality of training provided,
- the poor quality, the lack of availability and the lack of training in the use of learning support materials,
- the inability of provinces to support implementation, especially teachers in classrooms,
- the lack of human and financial resources and unrealistic time-frames.

As a result of the above problems, teachers have been faced with many challenges in the implementation of the new curriculum in their classrooms (Newstead and Bennie, 1999; Roux, 1999; Taylor and Vinjevold, 1999; Themane and Mabasa, 1999; Khulisa, 2002 and Pillay and Sanders, 2002). Teachers need to be able to,

- use learner-centred activities in their lessons,
- prepare lessons (assessment practice, lesson plans, outcomes),
- carry out instructional practices or handle classroom teaching approaches (learner-centred and the production of teaching aids),
- teach paced learning,
- use relevant examples,
- interpret the specific outcomes,
- teach the content, and
- develop a conceptual understanding,.

In order to overcome such challenges and difficulties that teachers are experiencing, there is need to provide a progression of training for the teachers who are implementing the changes in the classrooms. This is important because the implementation and success of any curriculum innovation lies with the teachers and the provision of professional development becomes crucial (Sanders, 1999). According to Hargreaves and Lo (1998: 4) *"it is teachers, more than anyone, who are expected to ..... develop the capacities for innovation, flexibility and commitment to change that are essential....."*.

The difficulties that teachers have been experiencing in making changes demanded by the new curriculum based on learner-centeredness (Black and Atkin; Van den Akker cited by Sanders, 1999) are partly because of poor qualification as outlined earlier. According to Fleisch, *"there were deeper problems beneath the teacher performance crisis, aided by the fact that educators were poorly prepared during pre-service training"* (The Teacher Newspaper, 1997). For instance, The review of Curriculum 2005 reported that *"although most teachers received some form of training, the training was generally regarded as insufficient and at times inappropriate"* (Chisholm, 2000: 7). A study on the understanding and implementation of *Curriculum 2005* in some primary school classrooms in KwaZulu Natal and Mpumalanga provinces in 1998 showed that some teachers felt that their preparation for *Curriculum 2005* implementation was inadequate and incomplete (Jansen, 1999a/b). Themane and Mabasa (1999) reviewing the literature also claimed that even after workshops in 1998, teachers still did not know what was expected of them in the classrooms because they were not well trained to implement *Curriculum 2005.* This reduces the level of confidence in teachers to engage in professional development.

Secondly, Sanders (2000) argues that the government has placed responsibility for the success of *Curriculum 2005* and the development of materials squarely on the shoulders of the teachers. Teachers are expected to be equal partners in the development of programmes and materials. This has been a huge responsibility for teachers who are not trained for *Curriculum 2005* and who are poorly qualified to undertake these demands without help (Rogan, 2000).

This study was carried out to try and assist teachers to meet the requirements and demands of *Curriculum 2005*. A computer package was developed which integrated learner-centred activities and real-life examples to teaching human population dynamics. The next chapter looks at the development of the package before it was administered to the teachers and expert reviewers.

CHAPTER THREE

THE DEVELOPMENT OF THE WEB-BASED PACKAGE

This chapter discusses the development of the package, and the model used to guide the development process. The development model used in this research incorporated four of the five stages (goal planning stage, establishing the context stage, design stage, production stage and the implementation stage) in a model suggested by Sanders and Linkonyane (2001), with an additional stage (preparation stage) included by the researcher.

3.1 THE DEVELOPMENT MODEL USED

The model of stages in developing the package included the following;

STAGE 1: Plan goals

This stage involves specifying the aim of the package to be developed. The purpose of planning goals is for researchers to formalize what they want to achieve. Patton cited by Sanders (1987) points out that *"if you don't know where you are going, you will have difficulty figuring out how to get there, and you won't know when you have arrived".* Formalizing goals in the design of instructional materials is important so that researchers do not go off track during the development stage. The stated aims act as a target which directs the design. Importantly, Sanders (1987) states that *"if you know what you are trying to do, you are more able to make rational decisions on how to get there".* Therefore, if designers know what they are trying to achieve, it increases their chances of selecting the appropriate methods for achieving their goals.

The goal for the development and evaluation of the package was suggested by the supervisors who had much knowledge in the field of instructional materials. The supervisors from their experiences and from what was going on in the educational transformation of the country, were aware that there was need to develop instructional materials for teachers who are implementing the new curriculum. The researcher constantly consultated with the supervisors for clarity on the goal of the package from the beginning of the course. The purpose of the package was to "help teachers use an science-technology-society approach to teaching about human population issues". Looking back at it, this goal was perhaps inadequately formalized, a limitation discussed in Chapter Five under the section on limitations of the study.

STAGE 2: Preparation stage for developing the package

This "preparation stage"is the additional stage added to the development model outlined by Sanders and Linkonyane (2001). The preparation stage involved the researcher going through a number of steps in preparing herself in order to gain the necessary knowledge and skills that are required to produce good quality instructional materials, especially computer-based ones. This was done in two ways, reviewing the literature and attending a course (Educational Technology in Science Education). This stage was important so that the researcher could use the advice thus gained when designing the package. Below are some preparations that the researcher went through.

i. ***Thinking about how computers can be used in improving the teaching process.*** This included what computers **can be used for** as well as the **benefits of using computers** (as a teaching and learning approach). These two have been discussed in detail in Chapter Two (section 2.2) on pages 14-19. The aim of doing this was to promote awareness and understanding of the importance of educational technology and its role in the teaching and learning science. Two broad questions were considered.
   - for what purposes can teachers use computers?
   - for what purposes can learners use computers?

   One particular use of computers was later utilized in the package that graphs developed in spreadsheets can be manipulated to instantly visualize changes in the spreadsheet data, so computer users can instantly see changes in relevant variables. The package used a spreadsheet (for simulation and visualization purposes) to explain the process of population decrease due to the AIDS/HIV disease in South Africa. This allowed teachers to visualize the drop or increase of the population on a chart whenever the figures in the table were changed. Therefore, teachers were able to visualize complex processes which are not possible with educational aids such as a whiteboard or an overhead transparency, which are two-dimensional and static.

ii. ***Designing a personal web page in order to master skills involved in designing web-based software***, including understanding the nature and use of Hyper Text Markup Language (HTML). This was an important stage which introduced the researcher to one of authoring package (DreamWeaver) used for designing the instructional materials. The researcher learned different skills (i.e. technical aspects) needed to design web pages. Other skills included planning on paper the layout of the package before it is developed, designing and the actual developing of the package. The type of skills learned in this course included;
   - creating folders and sub-folders in Dreamweaver 4
   - knowing how to make links and thumb nails to an internal and external source (e.g from one file within a package to another)
   - saving files and sub-files in folders
   - finding and saving clipart from copyright-free web sites
   - modifying and inserting graphic images using Corel Photo House, Wordperfect etc

- drawing and inserting HTML-based mind maps
- designing an effective navigation system
- using frames in web design

iii. ***Designing an interactive learning experience using spreadsheets.*** The purpose of this part of the course was to get students doing the course thinking carefully about one way of making teaching and learning material more interactive by using spreadsheets exercises. This exercise involved,

- identifying a suitable topic which lends itself to using spreadsheets, that is, a topic which involves tables of data, requires calculations to be done and requires graphing activities.
- providing a written lesson plan which included,
  - describing the target group for the programme, for instance, age or grade, subject area, topic, concepts, time allocation etc.
  - indicating the learner outcomes (what learners will be able to do, or attitudes they will develop after completing the learning activity).
  - listing items the teacher needs for the lesson.
  - explaining how the computer/activity will be used in the lesson, which included the role of the teacher (e.g how teachers might introduce or conclude the lesson).
  - describing what the learners will be doing in the lesson.
  - timing for various parts of the lesson and the total duration.

iv. ***Designing instructional software.*** The purpose of this part of the course was to introduce important basic concepts which impact on how computer-based instructional software should be designed. The aspects looked at included:

- considering the steps a designer needs to go through when planning and designing instructional software.
- considering the guiding principles of an instructional designer such as,
  - what can be learned from learning theories about how the software should be designed for effective learning (discussed in more detail in Chapter Two, section 2.3.1, pages 20-26).
  - what can be learned from research on teaching and learning about effective education.
  - what can be learned from research on interface design of computer-based materials, or from research done on effective design of computer-based instructional software.
  - guidelines to instructional design one should bear in mind when designing computer-based courseware.

The researcher then used this information to construct guidelines for a beginner instructional designer that need to be taken into consideration in order to design good materials. The importance of this was to find out how effective learning and teaching happens which could be applied to the design of the package. The guidelines to instructional designers was necessary for the researcher to know what aspects need to be considered in order to produce a good quality package.

V. ***Evaluating educational software .***

The Practice: The purpose of this part of the course was to evaluate computer software. This involved looking for good-quality evaluation tools/instruments or examples of good and weak designs so as to get ideas and to know what to avoid.

The researcher reviewed a range of programmes to see the sorts of criteria to consider when judging the worth of software. This involved locating some suitable evaluation instruments, critically assessing how useful they would be for examining the quality of software, and then modifying them so that they meet the researchers' needs, and then using them to evaluate two packages. This was important so that the researcher could recognise good and bad courseware, and be able to select and incorporate good practices into her own package.

STAGE 3: Know the teachers and the learning situation

This stage involves analysing the context in which the courseware to be developed will be used (i.e analysing the whole context situation). This is important in order to identify what the problem is and the necessary needs to be meant. Sanders and Linkonyane (2001) point out that it is difficult to design appropriate instructional materials without conducting a situational and a needs analysis.

The situation analysis involves looking at the current state of affairs with teachers and their teaching practices as well as identifying any problems which might exist. This is usually done by means of a survey so that the researcher can go out in the field to interview the intended users of the instructional material so as to find the problems being experienced. Because of the need to limit the scope of this study, the situation and need analysis was done by means of a literature review of publications and research relating to *Curriculum 2005* and the teaching approaches used in teaching biology and geography in South African schools. The designer looked at literature about what is going on in schools (such as the demands of the new curriculum) and if teachers are meeting them.

The situation analysis in this study involved looking at the current situation in South African schools in terms of teaching human population dynamics in biology and geography and what kind of demands the new curriculum makes. The researcher reviewed literature about

- current approaches to teaching human population dynamics with a special emphasis on problems identified by educators and researchers (discussed in section 1.2 in Chapter One).
- demands of the new curriculum . The requirements of *Curriculum 2005* are discussed in more detail in Chapter One (section 1.4) on pages 3-4.
- how teachers were coping with implementing the new demands.
- the provision of support for teachers to help them cope with the changes and new demands.

A needs analysis involves looking at what the users need, either by doing a survey or asking people involved. The needs investigate include aspects such as physical and setup provisions, school management etc. This is important so that the designers of instructional material tailor the package to

the specific needs of the people using it. Zammit (1992) carried out a study with 352 teachers in order to investigate which factors were perceived to facilitate or hinder the use of computers in teaching. In her study she found that teachers were less likely to use computers if they felt the software was not suitable for their purposes. Some teachers thought the available programmes were unsuitable, because they were either too narrow, too basic, too difficult, too inflexible, or emphasised rote-learning (which these teachers would like to avoid). Most of these teachers were looking for software that fitted into their curriculum and that complemented and extended the work done in class.

Such findings are very important and applicable in South Africa. For instant, Sanders (2001: 15) points out that her experience *"in South African schools suggests that this has been the major problem preventing teachers from using learning materials made available to them because they are never suitable to what the teachers want"*. Such problems can be avoided by doing a needs analysis because the developers of instructional materials would be aware of what the users want or are in need of. According to Draper, cited by Sanders (2001: 16), *"the most successful instructional software is that which closely fits the niche in which it is being used"*.

In order to take this into consideration, the researcher reviewed the literature on the demands of *Curriculum 2005* because teachers had to meet these requirements. From the situation analysis, it had been noted that there was a problem in the way human population dynamics was taught in schools, because teachers based their teaching on a teacher-centred approach instead of a learner-centred approach. However, the demands of the new curriculum required teachers to make lessons relevant to the learners' lives, actively engage learners in activities, develop a variety of skills and assess the learners continuously as discussed in Chapter One.

STAGE 4: Design stage

This stage involves the process of planning and writing down the structure and the content of the package (Phillips, 1997). It is important that the designers put everything on paper and create a storyboard of all the content of the package in order to produce good quality instructional material. Phillips recommends that the instructional designer conducts a brain-storming session with various experts who have a range of experiences, when starting to design the package. This is important in order to clearly define the functionality and scope of the study. It is after brain-storming that the designer develops a description of the content of the package. This stage is importance because the designer can discover problems and rectify them at this early stage rather than doing it in the production stage. In so doing, Phillips (1997) claim that time and effort can be saved, and costly mistakes avoided.

The purpose of writing down on paper for the researcher was to,

- help plan on paper what will go into the package, that is making a hierarchical layout of folders and files
- help organise thoughts,
- help avoid losing files since it affects creation of links

- help think about how to organise the screens into specific areas

Consultations with experts

It is important to talk to the experts when designing materials so that they could guide and advise the designers. The details on responses obtained about the package from expert reviewers are discussed in Chapter Four (research findings). Three expert reviewers (an STS lecturer and two instructional designers) were consulted during the design stage.
The STS lecturer was asked to;

- check the suitability of the STS teaching approach being used and whether the package is really using it.
- check the accuracy of the content (to check if the content is factual and based on the topic "human population dynamics")

The instructional designers was asked to;

- check if the navigation system proposed would be easy for teachers to understand and follow.
- check if the layout and format of different screens were suitably designed

STAGE 5: Production stage

The production stage involves working in a cycle which includes developing and evaluating the instructional material and if necessary going back to redesign certain aspects which are not working out (Phillips, 1997). It is at this stage that the actual programming work is done. The major task at this stage is to make sure that everything outlined in the design stage is working. The evaluation or testing of the package is therefore vitally important at this point. The package is tested through a number of development cycles so that any faults noted can be fixed. However, if the design stage was properly done, fewer problems are likely to arise at this stage, because these will have been resolved during the design process (Phillips, 1997). This stage depends on the previous stage because any changes made to the package may affect other screens which may also cause problems with other parts of the package.

For the package investigated in this research report, this stage involved working on the actual package and ensuring that all the aspects discussed in stage four were functioning. The researcher

- checked if the navigation cues (mind map, buttons) and links were working
- checked that graphics which had some movement eg the clock were functional
- made sure that the spreadsheet (chart) used in the package could change when the numbers in the table of HIV/AIDS figures were changed.
- made sure that all the exercises designed in Microsoft word were protected to prevent the users changing the content of the package when they typed their answers into the worksheet.

Whilst designing the package described in this research report the following design steps were followed, and expert checks done. While designing the package, there is need for experts to check if the designer is working towards the development of a good quality package which meets the stated aims. Below is a

table showing the advice that the instructional instructors of this course gave, and the modification made thereafter.

Table 5: Questions, feedback (three experts) and modification of the package.

Initial development: conducted whilst doing the course work		
Question	**Feedback from three "experts" who reviewed the package**	**Modification to the package**
Is the purpose of the package well explained to the users	• The STS expert reviewer was concerned that the package seemed to be for teachers who have computers at home only. She suggested that this should be changed. • Two experts were concerned that the package was resource material for learners instead of teachers. This was a major problem identified as the package was intended for teachers and not for learners. They advised that this should be changed.	The purpose of the package was re-worded to state that the package was a resource for teachers to use in their teaching.
Are the outcomes of the package well indicated?	• All the three experts said that most of the outcomes of the package are not stated as outcomes (e.g "experience an alternative approach", "see how STS places science in a relevant context" .)	The outcomes were re-worded as what teachers where supposed to be able to do at the end of the package (i.e using action words).
Is the package logically structured for teaching to take place?	• All three experts noted that the section on STS was very long. • The expert in instructional materials wondered if the first thing that teachers should look at be the STS approach to teaching, and not the content of lessons for learners. This is because the researcher is trying to teach teachers an STS approach to teaching.	The sequence of pages was changed to start with a home page (content of the package), outcomes, STS approach, population dynamics content and lessons.
Is the language clear enough for teachers to understand?	• Two experts said that some wording of sentences was not clear and well structured, and language problems existed. • Two experts said that some sentences were not addressed to teachers, but seemed to be for learners. • The expert for instructional materials warned that the researcher should be careful, avoid technical words and explain terms that the teacher might not understand. • Two experts suggested that the researcher should word some claims more carefully because they were not always true as stated.	• Instructions were written in simply English that teachers would understand. • Technical terms were explained.
Are the outcomes for each lesson indicated?	• All three experts emphasised that the researcher should include learning outcomes on all lessons. • All three experts emphasised that the researcher should state outcomes as what learners should be able to do at the end of the lesson.	Included outcomes for each lesson.

Are the activities interactive and clear enough?	• Two experts said that even though most activities were interactive, most of them were not clear and needed a bit of explanations. • The expert in instructional materials said that the researcher should clearly say where the materials for learners are to be found. • Two experts said that we want learners to actually do, not find out if they can.	• The structure of questioning and sequence were changed to engage learners in activities. • Activities were explained clearly to the teachers (what teachers and learners had to do). • The location of some materials and where learners had to write was explained.
Are the teaching lessons well structured?	• One expert said that the logic of some activities is confusing. • Two experts said that some articles included were not relevant to the issue of population increase. • All three experts said that the lessons seemed to be for learners rather than the teachers. • Two experts said that the topic (AIDS/HIV) is a very sensitive issue. Many people do not feel comfortable discussing it openly. The researcher had asked learners to give the number of their members of their families who had died of AIDS/HIV. The experts suggested that the wording should be changed. • One expert suggested that the researcher should include some lesson materials for learners to avoid scrawling up and down a screen to read the notes and then do the activity. • Two experts said that the teachers should be provided with as much information as possible for them to understand how to teach using an STS approach. • All three experts said that the researcher should allocate the time needed for the activities. • One expert said that the researcher should provide help on how teachers could answer some questions.	• Activities were re-written to include aim/purpose, time, materials needed, how to get the lesson started and how to conclude the lesson. • Instructions for teachers and learners were separated. • Sensitive topics like AIDS included questions that were meant for reflection only and others which were less sensitive were suggested for discussion. • Cut down on instructions for learners to hand-outs (lesson materials). • Questions were re-worded to provide much help for learners.
Is information up-to-date?	• The STS expert said that most articles were not up-to-date. She suggested that the researcher should try to get recent ones either from the Internet or newspapers. • The expert in instructional materials said that no background knowledge is provided for the teachers.	• Used articles from 1995 onwards.
Are the questions in lessons well structured?	• The expert for instructional materials suggested that the researcher should include questions for teachers to get the learners to say what they are doing with the figures on AIDS/HIV.	Questions were re-worded to get more information from the learners.

Are the instructions clear enough to understand?	• Two experts said that no instructions were given about where learners are supposed to write their responses. They suggested that the researcher should say if learners have to write into the worksheet given in Microsoft Word or in their books. • The expert in instructional materials said that some instructions were too vague.	Re-worded instructions.
Are references included to support statements made?	• The expert of instructional materials said that some statements were not backed up and that some articles did not have references. • One expert said that some claims were not scientifically correct. • The expert of instructional materials said that sources of diagrams needed to be acknowledged to avoid accusations of plagiarism.	All statement were backed up by references which where given in full on a separate page. References were added for all artwork carried from the sources.
Is the navigation of the package well designed?	• One expert said that the navigation should be changed , rather than using buttons, a mind map should be used on the first screen. • One expert reviewer said she was very confused, did not know where to start or what was in the package.	The navigation system was explained from the first page, thereafter the users where directed to make a selection of topics from the home page.

STAGE 6: Implementation stage (incorporate summative evaluation)

This is the last stage listed by Sanders and Linkonyane (2001), and involves the implementation of the finalized revised package. It often involves a summative evaluation as discussed in Chapter Four (section 4.1.2). This stage was not incorporated in this research as the scope of the study had to be delineated for the Masters degree. It is hoped that this stage will be followed up on later, as it is believed that the package will be valuable for teachers of biology and geography in this country.

3.2 USER INTERFACE

When considering the user interface, it is important to remember that the principal objective of user-centred design is to develop a programme that is so self-explanatory and easy to use that the need for manuals, on-line help or training is minimised or avoided (Hugo, 1996). Therefore, the user should be able to just look at the interface and immediately know what to do and it should be attractive and enjoyable to use. *It is essential to remember that the effectiveness and usability are the key success factors of a programme, and that tools alone do not guarantee a successful product* (Hugo, 1996: 127). The user interface must be effective since it determines the way in which a user will interact with the package. Below are some user interfaces that were considered in the design of the programme and the reasons why it was important to take them into consideration.

Table 6: Interface design

Area	Principle	Reason	Advice
Navigation and orientation	. Ability to move through the contents of a programme in a n intentional manner (Reeves, 1993). . Provide a user-friendly way of navigation through the programme.	. Users should know where they are, have been and where to go (Reeves, 1993). . Links should provide users cues for further exploration (Kennedy and McNaught, 1997). . Links should inform users about page organization and structure.	. Design a programme that is free of stressful navigation so that the users should not get lost (Reeves, 1993). . Use navigation tools such as table of contents, mindmaps, hyperlink buttons or indexes.
Links/buttons	. Navigation through the programme should be visible, clear and functional.	. To avoid users getting lost or getting frustrated (Kennedy and McNaught, 1997).	. Underline all links for visibility. . Be consistence with the position of the links/buttons. . Have links/buttons on all screens or direct users to the home page to make a selection.
Font/text	. Font or text should be clear, simple and consistence. . Font or text should be readable and brief to avoid scrolling through the screens.	. To enhance visibility and achieve best possible reading speed. . To avoid scrolling continuous text which may confuse, distract or irritate the user.	. Avoid the use of italics, all caps or bold letters which is difficult to read (Van Reenen, 1994 and Pellon, 1995). . Do not decorate font face for running text as it is difficult to read.
Layout and appearance	. Layout of information should be uncluttered, clean, short and consistence.	. To keep users interested in reading short information which is not displayed like a textbook full of continuous running text.. . To be consistence so that users do not have to adapt to new forms of text display on each screen as they are viewing the programme. . To avoid text being stretched out making it difficult to read.	. Avoid text layout which stretch out making the information difficult to read. . Avoid using different forms of text layouts which may confuse the users.

Images/graphics	. Graphics should be meaningful, have a specific function to that information and be of appropriate size.	. Graphics can motivate, retain attention or supplement understanding even when verbal text is straightforward. . Graphics provide an alternative mode for explaining and transmitting information (Pellon, 1995). . Large graphics takes longer to load frustrating the users (Williams, 2000).	. Graphics must support and enhance the written portion of the information (Burke cited by Pellon, 1995 and Smith, 1997). . Reduce the graphic sizes and save in a format that is easy to download.

CHAPTER FOUR

RESEARCH METHODS

A package on population dynamics was developed as a resource for teachers. This package consisted of the following :

- the aim of the package,
- a mindmap indicating the content of the package,
- learning theory on situated cognition, where theorists claim that effective learning occurs if knowledge to be learned is situated in relevant contexts,
- an outline of the STS approach which uses problems as the starting point in teaching,
- an outline on the human population dynamics content, and
- three lessons on human population dynamics

Teachers evaluated the package giving their views on the package and gave suggestions on how to improve it. Furthermore, two science educators reviewed the package after initial modifications were made from the responses obtained from the teachers.

4.1 EVALUATION RESEARCH

The principal aim of evaluation research is to collect information to support day-to-day decision-making (De Vos, 1998, Thornton and Phillips, 1997, and McMillan and Schumacher, 1993). Reeves and Hedberg (2001) argue that in developing interactive learning systems, there is a need to conduct various evaluation activities before making decisions. Evaluation means a judgement of merit or worth against a predefined set of standards or expectations (De Vos, 1998, Pham, 1998, Schumacher and McMillan, 1993, and Thornton and Phillips, 1997). They argue that the evaluation process is used to assign a value to the object being evaluated so that its worth or intrinsic value can be conveyed to others. The evaluation may include the review of draft scripts by the experts, observation of respondents using the package and subjection of the programme to thorough usability testing. However, Thornton and Phillips (1997) point out that the process of evaluating computer materials is not mainly to assign some intrinsic value to it, but rather to answer many questions that arise during the development and implementation of the computer material. For instance, the evaluation of the package in this study gave rise to many questions which were not earlier on formulated such as the design of lessons. The question that was often brought up was whether the package was intended for the teachers or the learners.

In evaluating instructional materials, most computer developers and users try to answer questions regarding how much better the developed programme is compared with any other approach to teaching.

This is important because the computer developers are constantly looking for ways of improving the effectiveness of the teaching and learning processes. The feedback obtained from these questions, using various methods of data collection at various developmental stages, can be used to improve and further develop the materials. There are two ways of evaluating learning materials, formative evaluation and summative evaluation.

4.1.1 Formative evaluation

Formative evaluation is used in research to find out how a learning material can be improved. Schumacher and MacMillan (1993) define formative evaluation as the collection of data to modify or revise material in a developmental stage. Formative evaluation allows the identification of areas of the programme which require revision, and which can therefore be used to improve the programme. Thornton and Phillips (1997) argue that formative evaluation can be used to provide a rich source of data about what the users think and feel about the interface and design. It is the information obtained from different research instruments such as questionnaires, interviews, expert review or observations that will answer questions that arise during the design and prototype development phases. Formative evaluation involves the systematic collection of information during the trial of the interactive learning programme for the purpose of making decisions about improving the product (Flagg, 1990; Reeves and Hedberg, 2001). Reeves (1993) claims that formative evaluation is the essential lifeblood of the instructional development process and it deals with how the product can be improved from its earliest stages of planning through to the implementation stage. The developers of educational packages carry out formative evaluation while the package is still under development, in order to support the process of improving its effectiveness.

Reeves (1993) says that during this stage of evaluation, the developer is interested in finding out if the programme or design works, by considering some of the following;

- the effectiveness of the navigation system,
- whether the intended users enjoy using the programme,
- whether the approach used to deliver the information is intuitive,
- whether the screen designs are effective, and
- whether the programme works in the way it was planned to (Reeves, 1993).

Whilst Pham (1998) believes that there are three major elements of an educational multimedia (computer) system that exert profound effects on its quality:

- the knowledge content of the product,
- the ways knowledge and tasks are represented and organized, and
- the technical tools used for conveying and constructing knowledge.

In formative evaluation, these results may lead to a decision to revise the material, to extend the field testing to gather more data, or to abort further development in order not to waste resources on a programme that ultimately may be ineffective (Schumacher and Macmillan, 1993).

In evaluating the package, Reeves (cited by Thornton and Phillips, 1997) and Pham (1998) strongly argue for three primary principles of contemporary cognitive learning theory that have to be addressed;

- learning is a process of knowledge construction as opposed to knowledge absorption (constructivism),
- learning is knowledge-dependent and uses existing knowledge upon which to build new knowledge (meaningful learning), and
- learning is highly tuned to the situation in which it takes place (situated cognition).

These principles have been discussed in Chapter two.

4.1.2 Summative evaluation

Summative evaluations on the other hand are conducted once the programme is fully developed (Schumacher and MacMillan, 1993), and with the purpose of judging the worth of a programme as a whole. According to Thornton and Phillips (1997), summative evaluations attempt to obtain absolute measures of the key underlying variables involved in the learning process. This approach is often used to compare the effectiveness of two or more instructional approaches.

4.2 RESEARCH PARADIGM

During formative evaluation, the eclectic-mixed methods-pragmatic paradigm was used. This paradigm borrows methods from several paradigms to collect information in order to solve a problem. It uses mixed methods to provide multiple perspectives on a problem, to triangulate information and draw conclusions (Reeves and Hedberg, 2001). Questionnaires and expert review were used to triangulate information.

4.3 RESEARCH ETHICS

Cohen and Manion (1994) believe that researchers ought to find a balance between the demands placed on them as professionals in pursuit of truth, and their subjects' rights and values which are potentially threatened by research. MacMillan and Schumacher (1993) point out that ethics deal with beliefs about what is right or wrong, proper or improper, good or bad. There are guidelines to what is ethically correct in research where the issue of ethics becomes important and should be considered. Below are some ethics that the researcher considered in the research.

- Told participants that their involvement in the research was voluntary,

- Gave a thorough explanation of the purpose and nature of the research before they participated giving the respondents a good reason for cooperating (Fraenkel and Wallen, 1993). This was done through a written note which explained what was being asked of the respondents and why. The purpose of this note was to motivate the respondents to fulfill the request.
- Participants remained anonymous and information was treated with strict confidentiality, as suggested by Bell (1987).

4.4 SAMPLE

Ten teachers evaluated the web-based package. These participants were selected purposively, by means of convenience sampling. The teachers were registered for an STS honours course at the University of the Witwatersrand and were invited to participate in the study. All were practising teachers registered for part-time studies, and all had taught at high school level before. Only volunteers were involved in the evaluation. However, only nine of the teachers returned their questionnaires. The sample size was small because the intention was not to make it representative of the whole teachers' population, but rather to evaluate the package developed and find ways to improve it.

Two science educators from the same institution also reviewed the package. One was an STS lecturer and the other one was an instructional designer.

4.5 METHODS OF DATA COLLECTION USED IN THE STUDY

Two main types of research instruments were used in this study to collect information from the participants, to provide multiple perspectives and to triangulate information. Phase one of the study involved teachers working with the package and answering a questionnaire. Phase two of the study involved expert review which required the STS lecturer and the instructional designer to talk-through the package and give criticisms and appreciation of the package.

4.5.1 Questionnaire

A questionnaire containing both open-ended and closed-ended questions was used to collect information from the teachers who participated in the study (see appendix A). Questionnaires are a data-gathering instrument used to obtain factual data, opinions and attitudes in a written format (Galfo, 1975). The questionnaire is self-administered by the respondent (Fraenkel and Wallen, 1993).

Design and development of the questionnaire

According to Gay (1981) the questionnaire should be as attractive and brief, and as easy to respond to, as possible. Below are some advice on designing a questionnaire that the researcher considered in this research.

Table 7: The advice on designing a questionnaire

DOS	**REASON**
Had to be attractive (Fraenkel and Wallen, 1993).	The appearance of the instrument was important to the overall success of the study (Fraenkel and Wallen, 1993).
Included unstructured questions which the responder had to complete, giving them freedom of response.	This permits greater depth of response and may permit insight into the reasons for responses.
Tried to keep the questions short (Fraenkel and Wallen, 1993).	To encourage respondents to respond by avoiding spending too much time reading (Fraenkel and Wallen, 1993).
Had to be as easy to answer as possible (Fraenkel and Wallen, 1993).	-the question asked exactly the way it is written -the question should mean the same thing to everyone -the question should be one that respondents will be willing to answer.
Questions had to be worded properly and clearly written (Fraenkel and Wallen, 1993)	Poorly worded questions can not yield desired results .
Used common language	To enable teachers to understand the questions.
Used follow-up questions (yes or no, explain).	They can make it easier for respondents to answer a given question and improves the quality of data received (Fraenkel and Wallen, 1993)
Did not present the questions on a single line, but rather used a table format (Fraenkel and Wallen, 1993).	To avoid respondents spending a lot of time reading questions which could discourage them from continuing (Fraenkel and Wallen, 1993)
Don'ts	**Reason**
The use of sloppy and lengthy questions (Fraenkel and Wallen, 1993).	Questionnaires requiring lengthy responses to each question turn people off which is not the way to get respondents answer the questions.
Avoided leading questions.	Leading questions gives the respondent the answer.
Avoided touchy questions to which the respondent might not reply honestly.	Touchy questions intimidate people who will give an answer to please the researcher.

The researcher used the advice on designing a questionnaire to design a questionnaire below. There was a rationale for asking each question in order to answer the research questions. Table 9 lists the questions asked and provides the rationale for each question.

Table 8: Questionnaire and rationale

QUESTION	QUESTION	REASON FOR ASKING
Question 1 Please fill in the details concerning the purpose of the web page.	Is the introduction of the web page complete and understandable?	The introduction to the package is important for the teachers to know what the package is all about. It also tells them who the package is designed for and what kind of contents are included. Therefore, the purpose of this question is to find out if from the introduction, teachers can understand the aim of the package.
	What is the purpose of the web page?	The purpose of the package if stated clearly will make teachers focus and have a good picture about the content of the package.
	Is the purpose clearly stated?	The purpose that is clearly stated will immediately help teachers know what they are supposed to be doing with the package.
	Does the homepage contain a well-labelled table of content?	Labelling of the contents is important to show what is contained in the package and if clicked will take the users to the stated information. Without this, teachers would not know what they are clicking on and what kind of information is contained on the link.
Question 2 Evaluate the web page for instructional use according to the criteria described below. 5=excellent 4=good 3=average 2=fair 1=poor	The title of the web page is appropriate for teaching human population dynamics.	To find out if the title is appropriate to the purpose of the package and its teaching approach. If this is not the case, the title can mislead the teachers.
	The topics of the web page are well covered and offer a wealth of information related to the human population dynamics.	In order to teach effectively, the topics of the package needs to be well covered so that it does not leave out some relevant aspects of the topic. Further, the information included should relate to the topic that is being taught otherwise it will mislead the learners.
	The web page contains original information which can be retrieved effectively.	It is important that the information is not borrowed from another textbook which teachers can easily use if they wanted to, but rather information needed to be up-to-date and relevant. It also needed to be based on an innovation approach which is learner-centred that would help teachers teach effectively.
	The content of the linked web pages is worthwhile and appropriate to the topic.	To find out if the linked pages on the web contained information that was relevant to the teaching approach and information in the package.
	The subject matter and content are appropriate and relevant to the teachers.	To find out if the topics being covered in the package are relevant to the teachers teaching biology at secondary level and appropriate for the topic. This is necessary if the package has to help teachers to teach the topic. It is also important in teaching STS that the subject matter is relevant. Teachers can use the STS topics to catch the attention of the learners.
	The web page contains accurate and reliable information.	To find out if the information contained in the package is based on facts. If it is not, most teachers may not use the package because the topics are different from the syllabus.
	The definitions of terms are provided when necessary.	Elaboration of terms help understand the content.

	The lessons are well prepared and structured (ie. time allocation, material needed, objectives, grade level to teach)	To find out if the lessons are structured in terms of time allocation, materials needed, concepts been taught under a certain lesson etc to help teachers in planning and timing their lessons.
	The activities (lessons) of the web page are interactive to the users.	To find out if the activities included in the package will enable teachers to actively participate in the learning process. This is important because one of the purposes of the package is to make it learner-centred as opposed to teacher-centred approach to teaching.
	The learners are encouraged to transfer the knowledge from the web site into their school and society activities.	To find out if teachers believe that the learners will be able to use the knowledge gained from these lessons and apply them into their everyday lives. One of the reason for the development of this package is to make learning relevant to the lives of the learners and applicable.
	The instructions given in the web page are clear and easy to follow.	To find out if the teachers could follow the instructions given and can easily understand what is being said. This is crucial for the understanding of this teaching approach and not to mislead them.
Question 3 How easy is it to find your way around the site and follow the activities? Please indicate the accessibility of the computer package by answering Yes and No and explaining your answer.	Can you move around the web page easily?	To find out if teachers are able to move around and follow the teaching approach. If information is not well linked, then certain information will not be available.
	Are there sufficient shortcuts or links available?	In order for the teachers to move around the package, shortcuts are important to use rather than clicking the back or forward button all the time.
	Are the links visually obvious?	It is important that the links are easily seen by the naked eye instead of the users having to search for them. Secondly, these links have to be a hot spot which is underlined so that when the user clicks on it, the intended information will be displayed.
	Are the links consistent throughout the web page?	Consistency in the links is also very important so that the users do not get confused. The use of different style of links can create many interpretations by the users as to whether the information is the same or different, whether it is supposed to be a link or not etc.
	Are the links clearly and accurately described?	Written text on the links or use of clip arts that describe the information to be retrieved is very important. The description of the links should be able to tell the user what kind of information can be retrieved from that link.
	Are the links active internally and externally?	Links which are not working are very annoying and irritating which is supposed to be avoided at all cost if the users are to view the package.
	Do the links take the user directly to the information?	Information that is not linked to the right pages can be annoying and irritating as well as confusing to the users of the package. The links should be able to directly take the users to the information.
	Is the web page organised well to facilitate the location of information?	The ideas is to find out if the links are designed at the same place and well organised such that it is easy to retrieve the information.

Question 4 Give your comments below about the structure of the web page.	Do the graphics and pictures serve any function to the web page?	To find out if the graphics and pictures used in the package relate to the content.
	Is the writing eligible and well laid out in attractive fonts and sizes?	To find out if the font is legible.
	Is the information well organised?	Readability is improved when information is well organised.
Question 5	Is the documentation and instruction of this web-based computer package on human population dynamics adequate? A) if so, explain why? B) if no, why?	Documentation: to find out if the STS and population dynamics content is adequately covered. Instructions: inadequate instructions can confuse the users who may not understand the package. A and B were used as probes for teachers to give an explanation on their answer.
Question 6	Are the tips for lessons (1 and 2) provided appropriate for teaching of this topic? A) It is appropriate, because... B) It is not appropriate, because...	To find out if the tips for teachers given in the package are helpful to teach this topic. A and B were probes for teachers to give a detailed explanation to the question.
Question 7	Do you find the www sites and other articles on AIDS helpful resources for the topic? A) yes b) no	To find out if the external web sites included are helpful to teach this topic. A and B had spaces left for elaboration
Question	Is this web-based computer package suitable for matric teachers? A) If yes, explain how b) If no, explain	To find out if the package is suitable for matriculation teachers teaching biology and geography. A and B were included to obtain further data on the suitability of the package from teachers.
Question 9	How helpful do you find this web-based computer package in promoting understanding of human population dynamics concepts? Please explain.	To find out if the package will help teachers to teach human population dynamics.
Question 10	Do you have any suggestions on how to improve the web-based computer package?	To collect ideas on how to improve the package so that it is more useful as a resource for teachers.

Pilot:

According to Gay (1981), a pilot study is sort of a rehearsal where a study is conducted and the results are analyzed. The purpose of a pilot study, even at small-scale pilot study, is to help refine procedures such as effectiveness of the questionnaire and in trying out analysis techniques. However, the larger the scope of the pilot study, the more like the real study it is, the more likely it is that potential problems such as uncontrolled variables and insufficient data processing routines will be identified.

In order to check and ensure rigour in this research, the questionnaire was piloted by two teachers who were not included in the main study. These teachers checked if the wording of the questions were clear, understandable and whether the instructions for answering the questions were also clear. The results obtained from this pilot study was used to inform changes in language and the layout of the questions.

This review of the questionnaire was important to check that the wording of the questions are clear and brief. Questions also needed to be carefully worded so that respondents can easily understand what is being asked (Fraenkel and Wallen, 1993). Therefore, an example of a good questionnaire would be that which Davidson described as; *"clear, unambiguous and uniformly workable. Its design must minimize potential errors from respondents.... and coders* (Davidson cited by Cohen and Manion, 1994: 93).

However, the pilot of a questionnaire to these two teachers may not have been enough because the results obtained after administering the questionnaire was poor. For instance, the questionnaire contained some questions that could not yield a lot of information. According to Gay (1981) the questions that calls for a simply "yes or no" response are problematic because they do not yield much data. Such questions were not identified in the questionnaire during the pilot study. In addition, the pilot study did not reveal poorly worded questions, questions that were not understood and instructions that were not clear to the respondent. The idea of having these two teachers was for them to identify major problems with the questionnaire (Gay, 1981) which was clearly explained to them before-hand.

The design of the questionnaire was modified as a result of this pilot study. The modified questionnaire appears in appendix A.

Administering:.

The questionnaire was administered to the teachers while they were using the package. This gave them an opportunity to write down responses whilst going through the package. However, the time (1 hour) that was allocated to them was not enough to adequately go through the package and give useful feedback. As a result, incomplete information, and inadequate explanations were often given. The researcher was present to give assistance that was needed such as clarifying and correcting any queries from the respondents. Three teachers who could not complete the questionnaire in time were given an opportunity to complete it at home.

From the questionnaire, teachers' views were sought about the coverage and content of the package, the instructions, the navigation/links, the presentation, the suitability of the package for matriculation teachers, its helpfulness in promoting the understanding of the concept of human population dynamics and suggestions on how to improve the package. Their responses to questions provided information on the teachers' opinions about the package.

It was important to have teachers interact with the prototype screens as early as possible, to compare their reactions and comments on the design of the package, the design strategy, the navigation system, the user interface design, the degree of interactivity, ease of use etc with what was expected from the stated objectives of the package. This is very important because what may have seemed to be clear and easy for the researcher in the design phase may not work at all with the intended users (teachers).

According to Thornton and Philips (1997) the features that were included during the design phase may cause problems and difficulties to the users such as disrupt their attention, misinterpret the information , destruct etc in the teaching process.

4.5.1.1 Advantages of questionnaires

One of the advantages of questionnaires is that they can be mailed or given personally to respondents at the same time (Fraenkel and Wallen, 1993). The researcher was able to distribute the questionnaires personally to all teachers before they viewed the package. This resulted in a high response rate from teachers.

According to Cohen and Manion, (1994), open-ended questionnaires are advantageous in that they allow respondents to be self-expressive through the use of their own words. It is further claimed that questionnaires yield meaningful information because the actual feelings of respondents emerge, making it possible to validate their quantitative responses and gain some insight into their reasoning (Hockey, 1995). This was not the case in this study because respondents did not have enough time to properly go through the package resulting in short and inadequate responses.

4.5.1.2 Disadvantages of questionnaires

However, questionnaires have disadvantages such as unclear or seemingly ambiguous questions which cannot be clarified (Fraenkel and Wallen, 1993) if the researcher is not available. Even though the researcher was available, it was evident from the responses obtained that teachers did not understand well some of the questions.

Questionnaires also have low percentages of return and incomplete responses caused by lack of comprehension and interest in answering the questionnaire. These problems were minimized because the questionnaires was personally distributed and collected from the respondents. The researcher was also available while the respondents were reviewing the programme, which offered an opportunity to clarify some queries and correct any problems encountered. As earlier pointed out, there was little time for teachers to view the package causing some teachers not to ask for clarification where they had difficulties in understanding some questions.

After some modifications based on the initial stage, the next step involved the researcher talking through the package with an instructional designer and an STS lecturer, both teacher educators, in order to obtain their views on how to further improve the package.

4.5.2 Expert review/verbal walkthrough

Schumacher and MacMillan (1993) state that the use of experts to make judgements about the worth of an educational programme is a time-honored and widely used method of evaluation. This expertise-based evaluation is widely used in qualitative research because expert review can not only identify problems, but they can also offer advice on how to resolve them (Thornton and Philips, 1997). The method involves two aspects which Schumacher and Macmillan (1993) calls connoisseurship and criticism.

- Connoisseurship is the process of appreciating (in the sense of becoming aware of) the qualities of an educational program and their meaning. In order to perform this, the connoisseur must have expert knowledge of the program being evaluated as well as of other relevant programs. The expert has a special appreciation of the program because of his/her intensive study of related work. As a result he/she will be aware of more nuances of an educational program than will a novice educator or lay person.
- Educational criticism is the process of describing and evaluating that which has been appreciated.

Schumacher and McMillan (1993) claim that the validity of educational connoisseurship and criticism depends heavily on the expertise of the evaluator. It is important that an evaluator is sensitive to both the strengths and weaknesses of the program being evaluated. The evaluator also needs to be knowledgeable about other programs, past and present in the same field of study. This is because expertise is one of the most important qualifications of an educational critic. However, Schumacher and MacMillan note that the validity of the findings from educational connoisseurship and criticism is entirely dependent on the expertise of the researcher-critic.

Two experts were consulted to provide comments and feedback on the package by verbalizing their thoughts and reacting to each screen as they worked through them. Their comments were recorded for analysis using a tape recorder. The STS lecturer reviewed the following issues:

- *the STS approach*: to find out if the researcher in the design is using an STS approach (i.e. starting lessons with an issue or problem, involving the collection of information about the issue or problem, evaluating and analysing the issue or problem, making decisions and taking action) and
- *the content*: Whether in using the topic on human population dynamics, the researcher has selected the appropriate materials within this topic (i.e. is the content accurate and does it meet the requirements of the syllabus on this topic?).

The instructional designer looked at the following:

- the screen and user friendliness of the package
- the instructional strategies used in the package
- general effectiveness of the package.

The critiques and appreciations obtained from expert review are summarized in Chapter five (table 16). The table also indicates some of the modifications that were made to the package.

4.6 USES OF DATA OBTAINED

Based upon the preliminary results obtained from the teachers when the package was first administered and used, the package was modified accordingly. Then it was viewed by the two experts and the results were used to refine and expand the package further. The purpose of using these research techniques was to determine the extent to which the package was achieving its intended objectives, and finding ways to further improve it.

4.7 DATA ANALYSIS

Qualitative and quantitative data was obtained from the two instruments, so open coding was used to analyze it. According to Macmillian and Schumacher (1993) coding is the process of dividing data into parts by a classification system. The purpose of dividing data into categories was for the researcher to rearrange or reorganize the data in order to work with it. During the coding process, all responses were put in common and meaningful themes that emerged, using the accepted procedures described by Cohen and Manion (1994) and Strauss and Corbin (1990). The researcher used the strategy of starting with predetermined categories, for example “coverage of the package in terms of content and instructions of the package”, “suitability of the package for matriculation teachers”’ and “usefulness of the package to promote learning of human population dynamics”’ as well as adding new categories that emerged as the data were analyzed. The final categories were not predetermined, but were obtained out of the data.

The next chapter involves a discussion of the results obtained from the questionnaire and expert review.

CHAPTER FIVE

RESULTS AND DISCUSSION

The results of this study have important implications for improving the package before teachers can use it in their classrooms. All quotes are given verbatim and the following trends emerged from the data obtained from questionnaires and expert review.

QUESTION: What is the purpose of the web page, is it complete, understandable and clearly stated?

Teachers were asked to fill in details on a number of items concerning the purpose of the package. Teachers' responses to a number of items revealed that they were not sure for whom the package was designed. Although some teachers realized that the package was intended as a resource for lesson preparation by teachers, it seemed that a number of teachers believed that the package was for use in the classroom as will be seen in the discussion below.

Table 9: Teachers responses according to the purpose of the package

Responses	Frequency (n=9)
to teach STS	1
to use computers to teach STS	1
to teach population dynamics through real-life	1
to give instructions and information	2
to introduction the whole package contained	1
No response	3

Two out of nine teachers indicated that the purpose of the package was to teach STS and to use computers to teach STS. These teachers may have meant that the purpose of the package could be to teach STS or for use in teaching because the responses given were not detailed enough to make conclusions. One teacher recognised that the intention of the package was to teach population dynamics using a computer package which uses real-life issues. However, the other three teachers said the purpose of the package was to give information and instructions as well as to introduce the package. This was contrary to the intended purpose showing that the explanation given on the purpose of the package was not clear. Nevertheless, six teachers when asked if the purpose of the package was clear, they all agreed that it was.

The purpose of the package was explained as shown in the abstract from the package below. This was before any modification was done from the responses obtained from the teachers and expert reviewers.

This site is designed for teachers teaching grade twelve in any school which has computers. The computer package uses a Science-Technology-Society approach to teaching human population dynamics. The theoretical framework behind the development of the package is Situated Cognition which emphasises use of real life examples to teach concepts. This makes learning interesting, and also relevant concepts.

In addition, there have been changes in teaching pedagogy from teacher-centred to learner-centred. This approach supports such a move as learning involves active participation of learners.

The STS lecturer also queried the explanation on the purpose of the package. Reading the text on the purpose of the package, she wondered whether the package was intended to help teachers with their lesson preparation or for class work. However, she thought it was worthwhile to have a school with computers because she can then perhaps use the programme like graphing. But she asked for some clarifications;

> *" So I think the question for me is* (pause) *do you want the teachers to take this programme and actually use aspects of it with the school kids?".*

This misunderstanding was as a result of the emphasis that the researcher had put across to the teachers that they should go through all the activities so that they could be able to know how to teach the content. But it was strongly cautioned that it should be made clear whether the teachers should use these exercises and then do them with their learners or make hard copies and do other activities with their learners. Reading carefully through the information, the expert reviewer agreed that maybe it is important that teachers should go through the activities so that they can understand the STS approach and how one can use the package in a classroom situation using computers. Therefore, it was well understood that if teachers understand the STS approach through this computer programme, then they will get an idea of how to use it in the classroom. This does not necessary mean that teachers have to use the programme in the classroom.

However, both lecturers who did the expert review acknowledged that the information given up front for the teachers was important because it gave the purpose of the package.

> *"I really like that bit of information that you have got here, it is telling the teacher the purpose of the package".*

The results from the teachers who used the package and from the expert reviewers revealed that the purpose of the package was obviously not clear and this had to be changed. The response from one lecturer justified this.

"But you are claiming that the package should be used to help teach population dynamics and I don't think that was the purpose at all. So that needs to be corrected".

Re-reading the statement on the purpose of the package, the instructional designer suggested that the statement should be changed to indicate that teachers will use the package to develop and understand skills on how they could use the STS approach to meet some of the demands of *Curriculum 2005*.

Part of the purpose included the outcomes of the package which one of the lecturers appreciated.

"It is a very good idea to have up front, what the outcomes of the package are..."

Question: How easy is it to find your way around the site and follow the activities? (Navigation/links)

According to Herrington and Oliver (1997: 134) *"navigation is provided in instructional materials to enable the user to move around and investigate the resource".* This is important so that users can locate and access information, move between related information, establish their positions within the information and be able to return to known screens.

Teachers were asked to indicate how easy it was for them to find their way around the site and follow the activities. All the eight teachers found it easy to view different screens of the package and to do the activities. The eight teachers said they could move around the package easily.

Table 10: Navigation

Question	**Response**
Can you move around the web page easily?	7 = Yes
Are there sufficient shortcuts or links available?	7 = yes
Are the links visually obvious?	6 = yes 1 = no
Are the links consistent throughout the web page?	7 = yes
Do the links take you directly to the information?	7= yes

Most of the teachers responded that the instructions were clear and some of the answers given included:

"Yes, there are key guides that makes it easy to access"

and,

"Yes, didn't experience any difficulties."

This was possible, because there were sufficient shortcuts or links on each screen and the instructions given on the computer could direct them. These links were visually obvious as they were highlighted in bold colours. For instance, one teacher said:

> *"The links were highlighted in bold colours and on every page there is a link to take you either back or forward."*

Below is an abstract from the package showing one example of navigation system and instruction that was given at the end of the screen before any modifications were made.



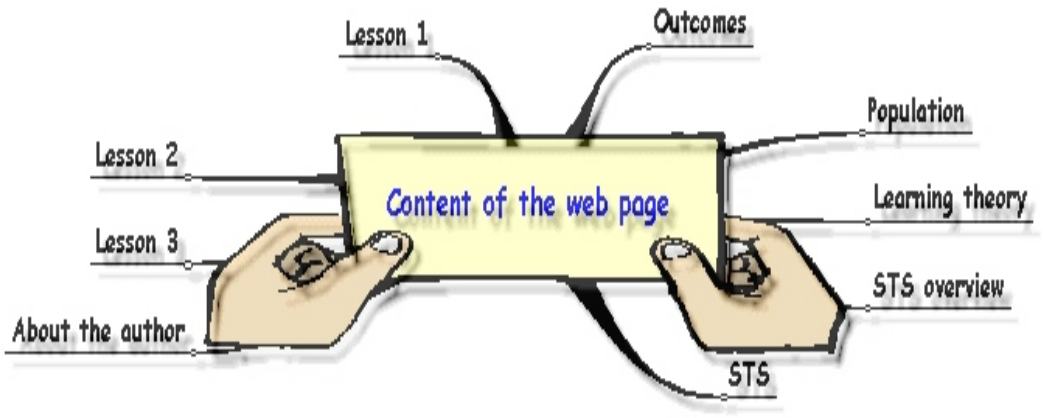
Please proceed to the learning theory by clicking the button below "Learning theory"

Homepage	Learning theory

However, one of the expert reviewer wondered if the mindmap on the content of the package could not be used to orient the teachers in the programme. In order for teachers not to get lost in the programme, this expert reviewer suggested it could be better to use the mindmap and maybe number the contents so that teachers could follow a particular sequence.

> *" I believe that if you want this mindmap to orient them to where they are in the programme so that they don't get lost, you can go back each time to this mindmap".*

One expert reviewer suggested that a mind map like the one below should be used to orient the teachers around the package. The users would always be told on each screen to go back to the home page and make a selection of the next screen to visit from this mind map.



Secondly, it was suggested that the instructions should be changed at the end of each screen. This was important because teachers can be given instructions on how to do it and the map would be one way of helping them to keep track of what they are doing. Without these instructions, teachers could get lost in the package. For instance, on the outcomes, this particular expert reviewer suggested that;

> *" ...I'd suggest that at the bottom of this page..... lets look at the learning theory next, to access it or to find information on learning theory go back to the concept map or the overview of the programme, either by clicking on the back button... or by clicking on home page".*

Therefore, it was suggested that at the bottom of each page there should only be buttons to take teachers to the home page (content map) and a back button to take them to the previous page.

> *" I think it would be easier for you to just have a home page, your content mindmap, a button which says back or previous page and lesson 1..... they generally know where it is they're going".*

This expert reviewer preferred to access lesson one and other information from the map because she believed that the map was going to get the teachers to check where they have been in the package.

Thirdly, it was suggested that an explanation should be given to explain why teachers should go to the next screen, ie the relevancy.

> *"Go straight to the learning theory, but you don't give the teachers any explanation why this is relevant, why do they need to know about learning theory...."*

Therefore, it was suggested that some introductory statement should be included such as:

> *" ....educational researchers have found that* (pause) *when teachers use methods in their classroom which are based on learning theories* (pause) *based on the research, has shown to be effective* (pause) *it actually improves learning in the classroom. One learning theory that has been used in this package is called situated cognition".*

It is after this statement that teachers would be told to click and find out more about what situated cognition is or any other topic and why it is important.

On the other hand, a number of appreciations were expressed on the directions given to teachers at the end of some screens such as:

> *" At the bottom of STS, I think that it's very good that you've said you can proceed to lesson 1....?*

Question: Give your comments below about the structure of the web page (Structure of the lessons).

Teachers and the expert reviewers gave similar responses on the structure of the lessons. Below is a table showing the responses from teachers.

Table 11: Responses on the structure of the lessons

Question	Response
The lessons are well prepared and structured (i.e time allocation, material needed, objectives, grade level to teach).	Excellent = 3
	Good = 2
	Average = 1
	Fair/poor = 0
	No response

Table 12 indicates that six teachers out of nine thought that the structure of the lessons contained in the package was well or averagely structured. The other three teachers did not respond to this question.

There was appreciation for the design of lessons by the two expert reviewers in terms of the way each lesson was structured, that is the time limit, materials needed for that particular lesson etc.

> *" I am glad to see that you recommended a time limit for the lesson".*

Going through the structure of the lesson, the STS expert reviewer said,

> *" It covers one parameter under this topic population decrease* (skimming through the text on the topic, she reads on) *the movement of population through mortality, okay, topic, mortality and decrease* (stops to read and explains what she understands on the topic) *so the general topic is population mortality and decrease..... grade twelve.....one and a half hours..... that is nice* (pause again) *subject, alright that is good looking, concept..... mortality in a population..... facts..... mortality .....okay so we've got all the facts".*

However, it was noted that there is no school in South Africa where one can find a lesson being conducted for about 1hour 30minutes. As a result of this, it was impossible to call it a lesson but rather a section of work. In order to cover the whole time limit required to complete a lesson, it was decided that each lesson have three half an hour sections or have a double period and a single period.

It was also acknowledged that it was useful to have something on facts, which in the package was not adequately explained.

> *" ...I think it's quite a useful idea to have a thing here on facts, but you don't indicate, are these the facts that will be taught to the kids? .....Are these the only facts that are going to be taught in this lesson? .....Are these the facts that teachers are going to know in order to teach the lesson? .....This , it's got to be made clear what the purpose is in this, and who the facts are for and whether these are the only facts or whether these are the two important things that students have got to know at the end of the lesson..... so that also needs to be made clear".*

Below is an example of a lesson structure that was used to indicate the time limit, grade, topic, materials needed etc of each lesson.

Grade

Grade 12

Total duration

1 hour 30 minutes

Subject

Biology/Geography

Concept

Population dynamics (mortality in a population)

Facts

1 Mortality indicates the number of deaths that occur in a population. It is the rate at which deaths occur and it can be shown as a percentage or as a definite number. Mortality causes a decrease in population growth.

2 The population size can be reduced by disease e.g. AIDS and HIV. Micro-organisms causing these diseases spread, usually by contact, more rapidly in a dense population. The disease can be a major epidemic decreasing the size of the population considerably.

Outcomes of the lesson

At the end of this lesson, learners should be able to;

-understand the concept of population decrease

-be aware of how AIDS/HIV can in some cases reduce the population numbers

There was also the issue of separating the tasks for the teachers and that of the learners. One expert reviewer said:

> *" Now you've got to be careful* (explaining) *because now you're in the middle of the lesson and suddenly you've got some information for the teachers. Any information for the teachers, you must keep it outside the lesson".*

Therefore, this expert reviewer suggested not to have lessons and lesson plans, but rather to just let the teachers move through the activities in the package. They also wondered if the researcher wouldn't have a certain box, every time in the lesson that something is being said to the teachers, it is put in that colour box. In addition, it should be made very clear up front to the teachers that although the lessons are for the learners, there is need while they are learning as teachers to explain certain things to them and it will always be done in that particular box.

With the lesson development, the expert reviewer supported the idea of having some discussions so that the teacher can see what learners already know (prior knowledge) before they came into the classroom. However, it was argued that the activity should be well structured so that teachers can easily understand what they are expected to do. It was revealed that most of the questions were not clear and had to be re-worded. For instance, on the discussion of AIDS/HIV statistics, it was thought that questions should be separated between the sensitive one and the non-sensitive.

> *" .... you need to say some of these questions are very sensitive and we've put them under the heading "questions for reflection only". So these are the ones that you're not going to ask children to talk about. You're going to give them to think about on their own..... just needs a clearer explanation".*

In addition, caution was given that care must be taken when working with real figures because some figures used in the activities were just examples.

The inclusion of a graph to illustrate the effect of AIDS/HIV on a population (i.e an increase or decrease in a population caused by this disease), was also well accepted.

> *" I must tell you, this is attractive, I like the look of your screen".*

It was also felt that it was a good idea to have the graph next to the table containing the figures which had to be plotted.

> *" Okay, I really like the idea of having this table right next to the graph so you can continually compare the figures on the table against the graph".*

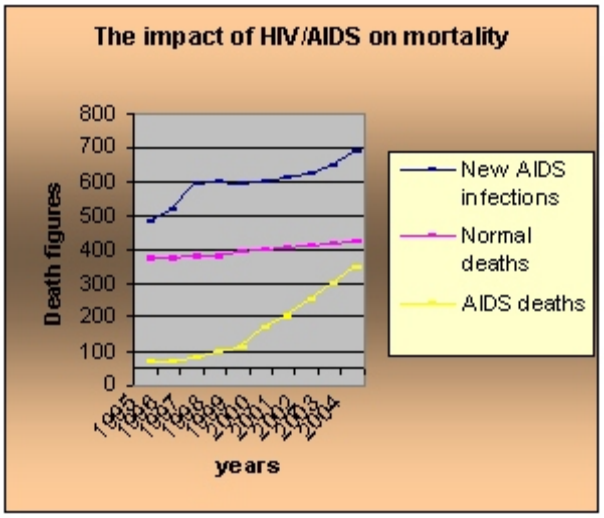
However, there were criticisms pointed out with the background of the graph, the colouring and the numbering of AIDS/HIV figures.

"One problem however, is this background. You've got this dark area in the middle exactly where your writing is (pause) *so you can not read that axis* (explaining in detail) *again your figures which you need in order to answer the question..... it is difficult to read those figures. Can you change the background colour of the legend..... can't be yellow because one of your lines is yellow, so you can't see it".*

It was revealed that the numbering and labelling of the axis containing the figures for the disease did not indicate the figures in thousands, but rather it read hundreds which was not the case. This caused a fear that the thousand was going to get lost over the table and in the graph.

Below is an example of how the table and the graph were displayed and designed.

Year	New AIDS infections	Normal deaths	AIDS deaths
1995	480	370	65
1996	520	375	70
1997	590	380	80
1998	600	380	100
1999	595	390	110
2000	600	400	170
2001	610	405	200
2002	620	410	250
2003	650	415	300
2004	690	420	350



QUESTION: Is the documentation and instruction of this web-based computer package on human population dynamics adequate?

1. Coverage and content of the package

Table 12: Teachers' responses on the coverage of the package

Question	**Response**	**Frequency**
The topics of the web page are well covered and offer a wealth of information related to human population dynamics.	Excellent	4
	Good	3
Is the documentation and instruction of this web-based computer package on human population dynamics adequate?	Covers concepts taught from the school textbooks.	3
	Covers all the steps required to teach the STS approach.	2

	Does not cover the whole content on human population dynamics.	1
	It contains general coverage.	1

Seven teachers felt that the coverage of the package was adequate and that the topics contained in the package are well covered, offering information related to human population dynamics..

> *"For Grade 12, I'd say yes, the information is enough for them to grasp the content." (Teacher G)".*

However, one teacher felt that the package did not adequately cover the content of "human population dynamics" required by the matriculation syllabus. She pointed out that the package:

> *"leaves out some aspects of the syllabus. If used some educators may stick to it and leave out some important aspects of the topic."*

This indicates that a note must be added to say that this package cannot cover the whole topic of human population dynamics therefore, the teachers will need to use other resources to teach aspects not covered here.

Two teachers clearly used their textbooks s a guide to what content should be covered in human population dynamics. One teacher commented on the package as follows:

> *"it links the issue to the textbooks provided, so it is not outside the context," (Teacher B)".*

This teacher was satisfied that the package incorporated the concepts found in the matriculation textbooks. This supports the research findings by Naidoo *et al.,* (1990) that the teaching of human population dynamics is generally textbook-centred. It also supports the claims made by Hockey (1995) that teachers rely on textbooks as the only source of information and that this contributes to the inability of teachers to engage in innovative teaching methods as well as to adopt meaningful approaches in their teaching.

A further two teachers felt that the package covered all the steps required to teach human population dynamics using the STS approach. For example one teacher said:

> *"Yes, it explains all the steps required in STS, teachers role, materials, learners' roles, method of assessment".*

2. Instructions

The responses from both the questionnaire and expert review clearly showed that most of the instructions were not clear enough for the teachers to understand what was being required of them. Teachers were asked if the instructions given in the package were clear and easy to follow.

Table 13: Responses on the instructions of the package

Question	Response
The instructions given in the web page are clear and easy to follow.	Excellent = 4
	Good = 2
	Fair/poor = 0
	No response = 3

Even though six teachers who responded to this question said the instructions of the package were excellent and good, one teacher suggested that the instructions of the package be improved and the reason given was:

> *"The learners instructions……. make sure that they are clear and you have actually applied them before using them".*

A major problem that arose from the instructions is that the intention or the purpose of the package was not clear to the teachers. This caused confusion amongst teachers and the expert reviewer as to who the package was intended for, the learners or the teachers?

> *" And one says why do we have to go through the activities that have been developed for learners.....you see those activities are been developed for learners and not for teachers".*

This expert reviewer explained that the language used in the package is often switched from whether the programme is for the teachers or whether it is for the learners.

The aim of the package was to introduce the teachers to an STS approach to teaching human population dynamics, which included various activities that learners would under-take, and the assessment of each lesson. However, the teachers needed to go through all these activities in order to teach the concept of human population dynamics using ideas from the package. The idea was if teachers understood the STS approach through this computer programme, then they would get the idea behind it on how to use it in their classrooms. It did not necessarily mean that teachers had to use the programme in the classrooms. In order to avoid this confusion, it was suggested by one expert reviewer that the wording of the information be changed to:

> *" ..... although the learners are going to be very actively involved in this lesson, the teacher has a vital important role to play, in fact, they have a number of different things they've got to do...."*

The instructional designer also made some criticisms that there were not enough instructions for teachers on how to go about viewing the package from one screen to another. This needed to be modified to include some explanations For instance, after viewing the learning theory, teachers were told to go to the screen on population content. But no explanation was given to justify the importance of doing that. Therefore, one lecturer said:

> *" please say, before one teaches this section of work, it is important that teachers understand the biology content. To review the knowledge that a teacher needs in order to teach this section, turn to the concept map and click on population".*

and,

> *" .....define and explain the concept population, ...now you're telling the teacher they have to define and explain population, and where must they do that? .....In their heads?..... On paper?..... You've given an instruction and you haven't given them enough information on what to do"*

and,

> *" .....but now teachers are going to be confused, what is lesson1?..... What is going on here? .....so you need to say something like, here is a sample lesson or we would recommend that you use three lessons to teach this, have a look at the three recommended lessons. Somehow you've got to tell them what is going on".*

One expert reviewer also indicated that there were a lot of assumptions made which needed to be explained clearly so that teachers could understand what was being asked of them.

> *" you're making a lot of assumptions that the teachers knows what you are talking about.* For instance, *" you're now talking about population dynamics lesson, and I am completely lost* (pause) *you haven't said that in fact in this package you've two lessons dealing with population dynamics or you're not telling the teachers what is going on and I think it's because it is so clear in your mind that you can't think that the people can get lost.....".*

In order to avoid these assumptions it was suggested that some explanations should be given to help teachers interpret the instructions.

QUESTION: Is this web-based computer package suitable for matric teachers?

Teachers were asked if the computer package is suitable for matric teachers. The purpose of this question was to find out if the package is suitable for teachers to use in teaching biology or geography. A number of responses were obtained as shown in the table below.

Table 14: Responses on the suitability of the package for the teachers.

Question	Response	
Is this web-based computer package suitable for matric teachers?	Yes	▸ For teachers to use in their lesson. preparations and use in classrooms. ▸ To enforce skills. ▸ To expose learners to science and technology.
	No	▸ Teachers are not computer literate to use computers. ▸ Computers limit teacher involvement.

One of the eight teachers thought the package was suitable for matriculation teachers because it could be used to prepare lessons and use in class. The response give was:

"The package was suitable for lesson preparation and use in class".

Whilst the other one who said the package was suitable for teachers said:

"Using computers in teaching is becoming a common and interesting practice which enforces the skill in both teachers and students. The topic will be used for such a purpose also".

The third teacher thought the package could expose learners to science and technology.

"It is easy to understand and follow. It is a good way to expose learners to both science and technology at the same time".

However, some reservations were expressed that the users of the package may not be computer literate. Concerns were raised about computer literacy and its effect on the use of the package:

"Would be easy if they are computer literate,"
Yes, but I doubt if most of the teachers are computer literate enough to make their learners learn easily."

According to Ward and Newlands (1998) greater use of computers will presumably improve people's computer literacy. One teacher observed that:

"It will limit teachers involvement and also hand-outs will be issued in minimum numbers."

This response may indicate the fear that teachers would be less involved in the teaching and thus would have less control in this learner-centred approach. This supports Naidoo *et al* (1990) research findings that showed that South African schools tend to follow a teacher-centred approach. It is also interesting that this teacher has misinterpreted the purpose of the package. This also reveals a problem in the design where the researcher was finding it difficult about who the package was designed for. The package is intended for the teacher and not for the learners.

QUESTION: How helpful do you find this web-based computer package in promoting understanding of human population dynamics concepts?

Teachers were asked to explain if they found the package helpful in promoting understanding of human population dynamics concepts. Two teachers said that the package would be helpful for the learners and also assist the teacher in dealing with certain topics taught under human population dynamics concept. Some teachers felt that the package was:

> *"Very informative, encourages learners to participate and regard issues as part of their own."*

In particular one teacher observed that the:

> *"Package included information from what learners are familiar with, linking learning with real life."*

According to Ausubel cited by Sanders (1988), meaningful learning occurs when the material to be learned is potentially meaningful to the learner. Pope and Gilbert cited by Sanders (1988) agree that meaningful learning will only occur if the content to be learned is regarded by the learners as having personal relevance. These responses indicate that the content used relevant issues that learners can relate to and that the activities are learner-centred.

QUESTION: Do you have any suggestions on how to improve the web-based computer package?

Teachers were asked to give suggestions on how to improve the web-based computer package. Even though most teachers did not give any suggestions on how the package could be improved, one teacher strongly suggested that the instructions be made clear. It was also evident from the responses that teachers would like the package to include all the topics covered under human population dynamics. However, this is not the intention of this package and it will be made clear to the teachers when the package is modified. Two other teachers said the package was well designed and only needed a few changes.

OTHER TRENDS THAT EMERGED FROM THE RESPONSES

Terminology/language

The responses from expert review showed that some terms used in the package would not be familiar to teachers and therefore, needed to be explained.

> *"...the computer uses a Science-Technology-Society approach* (reading and then pauses for a moment)*, ah, the main words in that explanation that I don't think I will understand.....they won't understand what situated cognition is..... which needs to be spoken, they won't know what theoretical framework is. So you need to use language that*

teachers are going to understand, because most teachers are not going to be at that level".

Therefore, it was strongly advised to use everyday language which teachers could understand.

" I can tell you, that is not teacher level language".

Layout of text

The most important advice in instructional design is not to display the information like a textbook, full of written text. But rather the information should be easy to read and attractively displayed. This aspect came up in the package, where for instance, the STS expert reviewer said;

"I find it boring on a computer programme to have continuous text..... so to me ..... it would be nicer again to have a sort of mindmap. Get away from the textbook language, give it in simplest terms, its got to be catching".

As a result, the STS expert reviewer advised that repetition of text should be avoided and the researcher should try to have as few words as possible on the screen which focusses on the key words. She felt a computer programme should excite a person and make them want to read facts and move on. Otherwise the users might as well be reading a textbook rather than use the programme.

In order to display information in an attractive and a simpler form, a number of suggestions were given,

"...do this as a bullet list.... carefully list the aims".

and,

" I would like to suggest that if you've got several different points that you're trying to make, instead of continuous text on a paragraph (pause) *that you consider using bullet list to make these points,* (explaining further) *because a bullet list is a way of helping the teacher understand the structure and if there is a lot of information, it's going to be much easier for me to grasp".*

It was argued by one expert reviewer that the importance of such layout of information is to allow the users to pick up the points just by looking at it and be able to visualize the whole thing quickly.

There were also some appreciations expressed on the display of information in boxes. Looking at the information given on the introduction of the section, one expert reviewer said;

"....I like that you've got this important (pause) *and then a box outlined in blue because it makes it easy to see...".*

and,

" I must tell you, I love these blue boxes, and they look very attractive and I think it is quite important to show the teacher what it is you're looking at".

The STS expert review also thought some of the layout of the lesson was nicely designed.

(Reading from the text: *" The movement of population through mortality and emigration causes a decline in the population*). *Now I look at that and then immediately it attracts my attention because you've got a heading..... and I really like the font you've use. Then you've got a short bit of text* (pointing to the text on the screen) *so it is not boring for me to read. That is only four lines and it has been put in a brown block. That is an interesting block and particularly the method uses a lovely graphic with AIDS on it".*

However, one of the expert reviewer strongly advised that there should be consistency in the display and colour codes in presenting information. For example,

" .....I think you need to be consistency in your colour coding throughout the package".

Secondly, the sequence of the content of different screens had to be re-arranged in order to render better understanding when teachers are using the package. For instance, it was advised that the STS approach to teaching should be brought earlier than the population content because the essence of the package was to teach teachers how they could use this approach which lends itself so well to *Curriculum 2005.*

" ..... trying to teach teachers about STS, and to me the first thing that you need to do is you need to introduce them to the STS approach.....section on content needs to come later.....first explain to them and linking it to Curriculum 2005 because you're telling the teachers, one of your outcomes is to link it to Curriculum 2005.....".

Font/size

It was generally felt that the font size used in the programme was nice and readable to the users.

" I like the print that you're using there, very nice and a mindmap there".

Colour

A number of comments from the instructional designer indicated some appreciation of good designs that were used. Nevertheless, it was pointed out that some designs needed improvements, for instance, looking at the heading of the package, one reviewer said;

"I like your rainbow colour heading (looking carefully at the words) *but I need to say that I find the light orange, the yellow and the light green impossible to read".*

and focussing on the type of content display of the package, she said;

"I really like the idea of having a concept map to show them contents of the package".

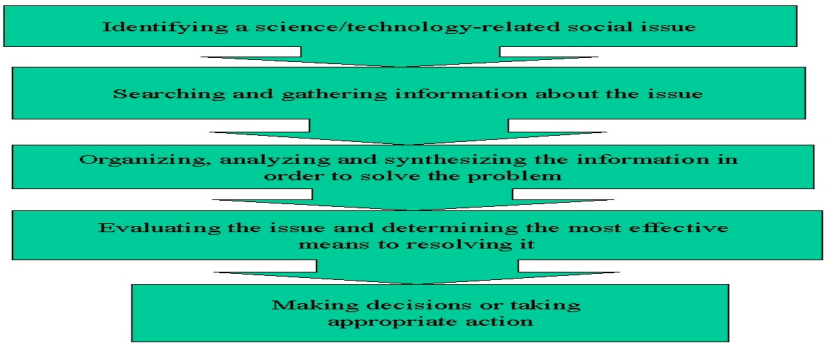


Use of graphics

There were some reservations expressed on the use of graphics for a variety of reasons. For example it was felt that some graphics stretched, becoming impossible to read the words.

" I must tell you that a lot of these graphics that you've put in are very difficult to read the- text..... it's really lost the words"

Most of these graphics mentioned were only impossible to read when inserted in the computer package using Dream weaver software. However, the criticism was taken into consideration because teachers may not read the text.



Other graphics were thought to have been used inappropriately as they were not corresponding to the content of a specific screen.

" Although you've got a beautiful graphic there saying AIDS, and then it comes to the heading topic, population mortality and decrease, it doesn't tell me anything about AIDS, I can't see the link".

The STS expert reviewer also expressed these reservations.

" I mean I don't know if AIDS is appropriate here (points to picture).

Presentation

Even though the package included newspaper articles that were well labelled with dates indicated, one teacher said,

"It would be more interesting if you could also include articles from newspapers and pictures as part of lessons. Provide the newspapers name and date."

Perhaps the newspaper articles were not well presented, or the teacher simply skimmed through the package and did not read carefully enough. The presentation of these newspaper articles were reviewed when making some modifications to the package.

Teaching approach

Even though the teaching approach linked so well with the *Curriculum 2005*, it was revealed that there was need to explain the approach very well. In order to do so, one of the expert reviewers argued that caution had to be taken to avoid teaching in a traditional method which the package was trying to avoid.

" And what I don't think you should be doing now is telling them how to teach, and in particular what you should not be doing is telling them to teach in a traditional textbook way which this is trying them to do, although you may not be aware of it".

The STS expert reviewer made several comments about the teaching approach used in the package, whether it was an STS approach or not. She also looked at the content of the lessons.

Lesson 1

The STS expert reviewer agreed that lesson one was using the STS approach because it starts with an issue which is relevant, it is using a local and national issue. In the STS approach, emphasis is on social problems, issues or events which are used as the starting point of learning (Hart cited by Hurd, 1989). Carefully reading through the lesson, the STS reviewer says the lesson focus on HIV/AIDS as a local issue by asking the learners questions about people they know and in particular, members of their family who have died of HIV in reflection questions. She explains that for instance, questions for discussion, you ask how many people have AIDS, dealing with figures they know. The STS approach uses activities which deal with problems affecting the learners' lives and society (Fensham, 1994) which in this lesson is HIV/AIDS. An example of the lesson structure is shown below.

QUESTIONS FOR REFLECTION

- Do you know of anybody who have died of AIDS in the past year?
- Have any members of your immediate and extended family died of AIDS/HIV in the past year?
- Do you know any of your friend's family who have died of AIDS/HIV in the past year?

QUESTIONS FOR DISCUSSION

These questions are probably insensitive and now they should be open for whole class discussion. In our example, we have the following figures, lets' use these numbers and make

the number we are trying to calculate x. In maths you have learnt how to solve for the unknown and this is what we are going to do here. Lets find x by doing the sum as in maths.

- How many people do you know? e.g. 30 people
- How many do you know of who have died of AIDS/HIV? e.g. 3 people
- What is the percentage of the total number of people you know who have died of AIDS/HIV? 3/30 of 100 = 10%
- If there are 60 people in your local community (in the area you live), how many do you think are likely to die of AIDS/HIV? To guide you, remember 3 people out of 30 people that you know have died of the disease, therefore, how many have died out of the total of 60 that are in your community?

3 - 30

x - 60
x = 3*60/30
Let's imagine for our example that South Africa had a population of 33 million and see how we can use our figures to calculate how many people are likely to die of AIDS in South Africa. Use your figures here.

3 - 30

x - 33 million
x = 3*33
million/30

In terms of activities used in this lesson, it was pointed out by the STS expert reviewer that this lesson uses a graph with AIDS statistics in South Africa which is a real issue. The STS approach deals with issues or problems which involves various activities such as analysing, investigation, discussing and debating were learners try to understand the science behind the issue or problem and find possible solutions to solve it (Ramsey, 1993, and Casey and Tucker, 1994). In interpreting the graphs, the learners would be interpreting and analysing the information about the national issue which is current and relevant

to South Africa. However, the learners would not be able to undertake the second step in this STS approach of going out in the field to collect information because they would be using the computers. But in order to investigate the problem of AIDS, learners are provided with predictions rates from 2005 - 2010 which gives them an opportunity to investigate the problem further. In the STS approach, the final step is for learners to propose ways to solve the problem based on the evidence rather than emotions (Ramsey, 1993) which was not included in this lesson.

Lesson 2

The STS approach requires a variety of teaching methods (Solomon and Akenhead (1994) were one of one could be simulation. The STS expert reviewer pointed out that activity one in lesson two was using a simulation activity which is often used in an STS approach. The activity also deals with a real and global problem of food and starvation which is necessary and a starting point in the STS approach. Learners are also given the opportunity to analyse the problem by identifying the stakeholders involved.

Lesson 3

It was pointed out by the STS expert reviewer that lesson three is also using an appropriate STS activity where learners try to investigate how HIV/AIDS has reduced the population size using articles on South Africa. They further collect more information on the issue from the Internet. Current newspaper articles dealing with some of the latest information on AIDS gets learners to analyse and find possible solutions to the problem.

These results have implications for further research if the designers of instructional materials have to achieve their objectives and effective teaching as well as learning.

Table 15: Feedback obtained from expert review and modification made thereafter

Second review of the package: Review of the package by an STS and instructional designer.		
Screen	**Feedback**	**Modification of the package**
Home page (front page)	• Used nice rainbow colour heading, but the light orange, yellow and green are impossible to read. • Gave up-front important information on the purpose of the package, but made claims that the package should be used to help teach population. • Did not explain the terminology “situated cognition” and theoretical framework. • Use bullet list for aims. • Used a good way to highlight information “blue box” with a title “important”. But re-word the statements. • Used a good idea of a concept map to show the contents of the package. • It is important to acknowledge all the other people who had the interest in designing the package.	• Changed the colour combination and font style. • The purpose of the package was re-worded. • Used language that teachers were going to understand. • Used bullet list for aims and explanations of the terminology “situated cognition” and theoretical framework. • Acknowledged all the participants to the design of the package (supervisors).
Outcomes	• It is a very good idea to have up-front what the outcomes of the package are. • Explain the word context for teachers to understand. • Aren’t other things that the package would teach? • Make the mind map on home page to direct the users on this particular sequence. Tell the users at the bottom of each page to click on either a back button or on a hot spot “home page” to take them back to the map. Give more instructions to avoid getting them lost in the package.	• Included other outcomes of the package and explained some terminologies into simpler language. • Directed users to go back to home page on each page in order to select the next page.

Human population content	• Give an introductory statement. • Be consistence in the layout and colour coding of instructions. • Be clear in your instructions to the teachers. • Don't make assumptions that teachers know what is being said. • Even though the idea of a diagram showing the concepts being covered and highlighted, outline clearly which concepts are being taught to help teachers interpret it. • Bring this section on human population dynamics after that of STS. • Link the STS section to *Curriculum 2005*, you seem to have ignored and missed that. • Give enough information for instructions, such as what to do, how to do it and where to do it. • Don't tell teachers how to teach, especially teaching in a traditional textbook way. • Don't jump to conclusion that teachers would be interested in the vision and purpose. • Use everyday language and try to justify. • Explain what an issue is. • Consider using bullet list to make points of continuous running text or paragraph. This is important because bullet list is a way of helping teachers understand the structure and makes it easier to grasp information. • Most of the graphics used are difficult to read the text. • Start with a problem rather than an issue because people will very easily be able to find a problem in their area. They are going to struggle to find an issue. • Change some terminologies, like determine to propose, suggest or discuss different ways of resolving it and then make decisions about the issue. • State clearly that even though learners are going to be very actively involved in the lessons, the teacher has a vital important role to play. • Give clear directions at the end of the page.	• Outlined that before one teaches this section of work, it is important that teachers understand the biology content. • Gave instructions to teachers that they would go through sections listed below. • Clearly stated that the package was dealing with three lessons dealing with human population dynamics. • Explained that the package is still under development and only those concepts highlighted in red have been covered. • Gave suggestions why educators think that this approach is better. • Included a diagram showing different things teachers had to do.
Learning theory	• Give the reason why teachers should know about the learning theory. • Give them direction where to go next.	• Included an introductory statement "educational researchers have found that when teachers use methods in their classroom which are based on learning theory, based on the research, has shown to be effective. It improves learning in the classroom". One learning theory that has been used in this package is called situated cognition. • Directed teachers: to find out more about what situated cognition is and why it is important, click on it.
STS content	• Give clear directions at the end of the page. Can't say proceed to lesson 1 as teachers are going to get confused. • Change buttons at the bottom of the page. It would be easier to just have a home page or content mind map r a button which says back or previous page and lesson 1.Tell them where they are.	• Changed to say that there were sample lessons that were recommended for teachers to use which teachers had to look at. • Made teachers access lesson 1 from the mind map on the home page.
Lessons	• Re-word your sentences. • Give clear directions. • Link the graphics (AIDS) to the content of population decrease i.e mortality. • Used very attractive blue boxes to tell teachers about the time, materials and concepts being taught. • You will never find a lesson in South Africa that is 1hr 30m long.	

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions and implications

This study showed that instructional computer designing and computer teaching is complex and goes well beyond merely putting teachers in front of computers to teach human population dynamics. The implications of these findings are that a number of improvements need to be made to the package if it is to meet its objectives. However, the positive responses from the teachers (participants) are indicative of the fact that the use of computers in teaching can be implemented in the actual classrooms. This could be achieved if some teachers are able to establish familiarity with the use of computers in teaching.

Knowing how to operate a computer was one concern raised. Some teachers believed that computer literacy amongst teachers was very vital if teachers were to use the package. The concern of computer literacy of teachers did not form part of this research and it was made clear to the teachers during the modification stage of the package.

Despite the concern of computer literacy, many teachers in the sample were able to move around the package because of the simple navigation system that was used. Each screen had well labelled buttons which could be easily seen to take the users to the previous screen or the next screen.

It was also found in this study that some teachers seemed to have been concerned about the adequacy of the coverage of the topic, which left out some sections. These teachers felt that the package needed to cover all the topics under human population dynamics which was not the intention at all. The content and coverage of the package was well explained during the modification stage (i.e. after getting responses from questionnaires) to indicate that the package only covered certain sections under population dynamics.

The expert review also revealed a number of issues that were carefully addressed in the modification stage when designing this instructional package for teachers. Some of these concerns involve;

- the instructions which had to be made very clear so that teachers are able to understand what is required of them to do.
- the directions which are necessary for teachers to work through the lessons and other information were modified. This was important so that teachers could easily follow the STS approach to teaching population dynamics without getting confused or lost.

- the layout of the text had to be changed so that it did not look like a textbook full of written text, rather it should be short and direct to the point.

However, a number of aims were achieved in this package, for example, the package;

- introduced the teachers to the idea of teaching human population dynamics using an STS approach and to a learner-centred approach.
  - This package was able to provide teachers with useful ideas for teaching human population dynamics using relevant and real-life issues which is one of the outcomes for *Curriculum 2005*. The content of human population dynamics used different problems in real-world situations to make a link between real life issues and the content learned at school.
  - It also uses a learner-cantered approach and could be an effective resource for teachers to engage in innovative teaching methods.
- The use of this approach also linked so well with the outcomes advocated for in *Curriculum 2005*. For instance, using these problems to teach provides learners the opportunity to develop various skills such as critically evaluating of information, identifying, collecting, analysing, organising information on the problem and finding ways to solve it. This also offered the teachers opportunities to make learners work in groups. Furthermore, the content used in this package contained relevant issues linked to the textbooks used at matriculation level in teaching human population dynamics. This was important so that the syllabus was considered.
- Importantly, the reaction and attitude of most teachers who were involved in this study was very positive. If the package can be improved, it is most likely that most of these teachers would be able to use it in their teaching.

6.2 Recommendations

In this research, there are two major recommendations that could be made for future research. In order for the package to achieve its' aims, the package should be improved upon and teachers should use it in their teaching to see what kind of effects it will have on learning.

6.2.1 Improvement of the package

The package developed revealed a lot of faults that have to be worked upon. Therefore, one of the things that needs to be done to the package should be to improve it considering the responses obtained from the teachers and expert reviewers discussed in the results chapter (Chapter five). The package developed was only evaluated twice due to time constraints, resulting in inadequate information to improve on it.

In order to effectively evaluate an instructional material, a lot of time and input is required on the part of the researcher. Even though talking about textbooks, Doidge (1991) points out some of the problems that are also expected in designing instructional materials *" the production of excellent textbooks requires time, research and expertise. It also requires the piloting of textbooks in schools, evaluating and revision before they are published".* The lack of such important consideration and advice results in low quality computer materials that would not be in any way better than other teaching materials. Therefore, it would be highly suggested that the developed package be further administered to teachers and expert reviewers to obtain more information to improve the package.

6.2.2 Implementation of the package by the teachers

Secondly, it is the view of the researcher that administering the package by teachers in the actual classroom situation will be a more effective method to find out how effective the package is in teaching. Gauguly cited by Tsvigu and Maswera (2001) argues that for successful implementation of computer enriched teaching, more attention is needed in the area of educating the teachers who will use this technology so that learners interest and participation in the subject can be improved.

6.3 Limitation of the study

A major limitation of this study was the time frame given for the completion of the research. In evaluating instructional materials, a lot of time is needed because the researcher needs to go through several phases administering and collecting information in order to improve the material. However, there was only one year to complete this research, giving the researcher only two phases of data collecting from the teachers and the two expert reviewers. If there was more time, the researcher would have collected more feedback from different groups of teachers to improve on the package further.

The other aspect that was affected by the time frame is the planning of the development model in developing package. In order to properly and effectively develop a good quality package, there is need to consult with the experts and other people whilst going through the stages. This is important because the development of instructional materials requires careful planning and a significant amount of experimentation before software designers can come up with models that are effective. According to Phillips (1997: 36) *"Interactive Multimedia programs require considerable time and resources to create and, therefore, the development process needs to be as efficient as possible".* Phillips claims that it is important to complete the planning stages and do all the checks before the designer could start the production of the package. But this was not possible in this research because the time was not enough.

Secondly, the sample size of teachers was small which did not give enough responses on the design of the package. This could not be avoided because it was only this group of teachers who were suitable to give their views on the STS approach as they had done the course on it.

Thirdly, there was also little time (one hour) for the teachers to go through the package before they could answer the questionnaire. This did not offer them enough time to critically evaluate the package and give detailed responses. This limitation could not be avoided because it was the last session of their lectures.

The fourth limitation involved the pilot study where two teachers checked the questionnaire ie questions, wording, language etc. These teachers did not adequately and critically evaluate the questionnaire which obtained poor results in the main study.

6.4 Delimitation of the sample

Even though having a small sample proved to be a limitation to this study, it was chosen to limit the scope of the study. This was important to enable the researcher complete the research in the specified time frame for completion of the degree.

6.5 Concluding remarks

This evaluation research involved two stages and two methods of data collection. The researcher first used a questionnaire to collect information from teachers who worked through the package in its earliest stage of development. The second stage involved two expert reviewers doing a walk through the package and verbally giving their criticisms and appreciations of the package.

The responses obtained from both instruments (questionnaire and expert review) was used to modify the package. A number of appreciations were expressed about the package as well as criticisms which the researcher considered in order to improve the package. These appreciations and criticisms have been discussed in Chapter Three and Chapter Five. Based on the responses obtained from teachers and experts, some recommendations have been suggested on how the researcher may address them so that the package could further be improved upon.

This research has revealed that teachers are willing and appreciate to learn different teaching methods that could meet the new curriculum in South Africa. On the other hand, the research has also highlighted some of the problems that one may experience in designing instructional materials.

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