AN INTEGRATED APPROACH TO TECHNOLOGY EDUCATION AS A MEANS OF ENHANCING ACHIEVEMENT IN MATHEMATICS AND SCIENCE

By

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DECLARATION

I declare that "AN INTEGRATED APPROACH TO TECHNOLOGY EDUCATION AS A MEANS OF ENHANCING ACHIEVEMENT IN MATHEMATICS AND SCIENCE" is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

KHULEKANI ELLIOT STEPHEN SITOLE
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Many, many thanks to my late father. The sight of your face and your perseverance is always my inspiration. If I know more of you, I could be more successful. Thanks to my mother for her active involvement and drive. You are always wonderful. You will live for this day, time is still on its way. My wife has always been nagging, but Lungi, your patience and love will always be appreciated. Junior, I know you are continuously annoyed, you never had the time you deserved from me. Fortunately you always understood. Thola, Themba your words of encouragement are always welcome.

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Khulekani

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ABSTRACT

The purpose of this study is to formulate guidelines upon which Technology Education can be put into operation in the South African schools with specific reference to standard eight students. The objective is to formulate Technology Education guidelines suitable for and within the broad framework of the South African curricula.

In attempting to translate Technology Education curriculum to South Africa, the author explores the state of advancement in Technology Education in
various developed and developing countries. The status, principles and theoretical assumptions of Technology Education are also explored. The role of the teacher in the Technology Education programme is also discussed. Guidelines for Technology Education, including Technology Education teaching strategies, guidelines for Technology Education assessment standards and guidelines for integrating Technology Education, Science and Mathematics are also formulated.

The author qualifies the significance of Technology Education in South Africa through a pilot study over a year. The subjects of this (pilot) empirical study consisted of a total of 175 standard eight students, 77 of who were in a control group, who had received no tuition in Technology Education. A group of 98 received tuition in Technology Education for a year.

The normal end of the year examination in 1994 measured academic performance of the two groups. Performance in 1993 is also used in the statistical analysis. The Univariate Analysis of Variance (ANOVA) is applied in the analysis of data. Statistically significant differences are found between the academic performance of these two groups in relation to the overall Examination marks, English, Science and Mathematics marks.

Statistically significant differences are also found between the 1993 and 1994 performance of the experimental group after receiving Technology Education tuition in standard eight in terms of the overall Examination
marks, English, Science and Mathematics marks.

In the control group, no statistically significant differences were evidenced in Mathematics, English and Science when comparing marks in 1993 and in 1994. It is only applicable in the average Examination mark. These results confirm the role that Technology Education plays in enhancing performance in Science and Mathematics including English.

KEY WORDS

TECHNOLOGY; TECHNOLOGY EDUCATION; EDUCATIONAL TECHNOLOGY; VOCATIONAL EDUCATION; INDUSTRIAL ARTS; MATHEMATICS ACHIEVEMENT; SCIENCE ACHIEVEMENT; ACADEMIC ACHIEVEMENT; TECHNOLOGICAL LITERACY; TECHNOLOGY METHODS; PREVIOUS PERFORMANCE, HOLISTIC APPROACH, TEACHING ACTIVITIES; TECHNOLOGY 2005 PROJECT
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CHAPTER 1 - RATIONALE AND ORIENTATION TO THE STUDY

1.1 INTRODUCTION

South Africa tends to look towards countries with a superior industrialised economy in order to find solutions for local problems instead of looking at developing countries that have similar experiences as South Africa. Trends in developing countries could be a recipe enabling South Africa to offer an integrated education system. However, looking at both the developed and developing countries may help South Africa to come up with her own model converged from the two models. By implication South Africa should converge both ideas from developed and developing countries to come up with an integrated system to solve its problems with specific reference to educational issues which will be discussed later.

It is accordingly important for South Africa to note that before any superior achievement in industry can be expected, South Africa should find an education system ideal to prepare South Africa to be competitive in the international arena. This education system should strike a balance between the natural sciences and the humanities.
International competitiveness should not be looked at from a one-sided position, only as economic competition. It should rather be approached from a holistic position that also includes competition in terms of research, science, technology and the well-being of the citizens of a country. As mentioned earlier, such a level of competitiveness warrants a sound education system that could produce citizens who will contribute to the well-being of a country.

Having perused the global concern in this regard, the problem can be limited to the seemingly apparent problem in the achievement of students in high school Mathematics and Science. The alleviation of this problem area is but one of the factors which can contribute positively to a country's sound education system. The author will also like to mention that a dynamic education system is not necessarily the sole factor, which contributes to global competitiveness, and many other factors may relate to this problem. The same could be said about the importance of Science and Mathematics as well as Technology Education as ingredients of a dynamic education system. But Science and Mathematics is an area of concern to the author.

There is evidence of a continual disparity between performance in the natural Sciences and the Humanities in the South African education system. Many causes have been sighted for this disparity, as a result there seems to be minimal scientists in the South African community in general, which
seems to be even worse in the Black population. Although various educational organisations attempted to solve this problem, according to the author, South Africa currently experiences a serious shortfall of qualified Science and Mathematics teachers, with only a few qualified Technology Education teachers.

The apparent declining performance in Science and Mathematics is a matter of concern for the author. As a principal of a Technical High School in Soweto and later of a Technology College in Johannesburg, the author became aware of problems that students encountered in the achievement in Mathematics and Science. The author also attended a one year programme in Technology Education in Mississippi (USA). With this kind of background the author was prompted to look critically at the integrated delivery of Technology Education in improving performance in Mathematics and Science within the South African context, especially for Black students. It is also important to note that there may be a number of other factors that could contribute to improved performance in Science and Mathematics, but the author will deal specifically with Technology Education as but one of the factors.

1.2 ANALYSIS OF THE PROBLEM

Technology Education "as a people based discipline attempting to satisfy the needs and requirements of a specific community" (Cousins 1981:50)
seems to be the answer to the solving of South African technology development programmes. It strives towards equipping students and teachers with skills to find suitable solutions to satisfying needs and solving problems which are embodied in the environment, therefore preparing students towards the world of work (Johnson 1989:9).

The author is of the opinion that South Africa seems to have a massive problem regarding an inadequately skilled labour force. Technology Education as a means, which prepares students towards an industrial world, may be one of the answers in providing the South African job market with skilled labour. According to Braukman and Pedras (1990:9) Technology Education emphasises the analysis of problems and needs and seeks to provide practical, economical and efficient solutions, which meet the needs of society and the environment.

The Technology Education curriculum has been well advanced and developed in the United States, United Kingdom and other developing countries but its present development in South Africa seems to be quite insignificant. South Africa should compete with outside countries so as to be able to present a curriculum which offers technological advancement and which offers students exposure to solving problems and creating alternatives so as to satisfy human needs, therefore this insignificance should be attended to as a matter of urgency.
The author will be looking at this problem from a further education and training perspective. The place of Technology Education in the South African schools will be discussed. It is therefore imperative to note that the place of Technology Education in the South African schools of the future will be a "consequence of what education decided in response to the problems ahead and their understanding of how people can use Technology not how Technology uses people" Unruh and Unruh (1984:315).

According to Halperin (1981:81) the "continuing revolution in telecommunication, computers and other newer technologies will put a premium on the provision of workers with complex technological knowledge and skills." Therefore the author is concerned that South Africa should strive towards equipping its citizens with these skills and that it is through a Technology Education curriculum that not only attained techno-logical knowledge and skills can be manifested (enhanced) but also performance in Science and Mathematics can be enhanced. Having given the motivation and background towards the study, the author will briefly define Technology Education and also giving its nature, historical development and its significance.

1.2.1 DEFINING TECHNOLOGY EDUCATION

Technology Education is the "purposeful application of human knowledge of materials, sources of energy and natural phenomena" (School Council
It is a means of extending human potential and the relationship of human endeavours to individuals, society and the civilisation process (Hales and Snyder 1982:7). It is that area of the curriculum that teaches about how humans create the "technological world around us" (Dugger and William 1995:23). Technology Education, fundamentally, "consist of the use of efficient practices in order to solve practical existential problems and this entails the design and the use of tools and devices and the creation of artefacts" (Lewis and Gagel 1992:117).

Technology Education must not be confused with Educational Technology. Technology Education deals about Technology whilst Educational Technology is a means of teaching with Technology. It must also not be confused with Technology. Technology is the "application of knowledge, tools and skills to solve problems and extend human capacities" (Seymour 1993:5).

Technology Education is an ability to complete a task given and to find a solution to a technological problem. It is important to note that Technology Education is concerned with how in the human created world problems are solved and knowledge is applied to find solutions (Dugger and William 1994:7).

In summing up, the author defines Technology Education as a comprehensive action based educational programme concerned with technical means,
their evolution, utilisation and significance, industry, its organisation, personnel systems, techniques, resources and products of their social and cultural impact and how in the human created world problems are solved and knowledge is applied to find solutions. This definition will certainly focus on solving the imminent confusion about understanding the difference between Technology Education, Technology and Educational Technology.

1.2.2 NATURE OF TECHNOLOGY EDUCATION

The cognitive base for Technology Education not only includes the two domains, that of the Sciences and of the Humanities, it also includes a third domain made up of the compounding of individual technologies. The rational domain called "formal knowledge" results from these three domains (Hales and Snyder 1982:7). These three domains (cognitive knowledge base) interact with three adaptive systems namely an ideological system, which is a scientific based system, technological system, based on technology and a sociological system based on human dynamics. This is typical of the manner in which the social and the technological means of humanity evolved historically.

It is also important to note that the discovery of new knowledge helps people to adapt. Adaptation means to develop and improve. Through
adaptation knowledge of people is expanded. These means of adaptation become the curriculum base for the study of Technology Education. The fundamental context for supporting Technology Education are manufactured goods, constructed structures, communicated ideas and transported goods and people (School Council 1980:13). These are the results of adaptation.

Technology Education is seen as a process, as the purposeful application of man's knowledge of materials, sources of energy and natural phenomena. Technology Education has to do with the use of independent adaptation and evaluation of technologies. It entails "yearning for knowledge, confidence and experience of using a wide range of modern technologies, the ability to adapt them to their own particular purposes and to compare those that claim to be competitors for the same basic tasks" (Fensham 1985:416).

Layton (1987:594) recognises Technology Education "as an autonomous field coequal to a branch of Science but not subordinate to it". Technology Education, according to this author, is characterised by its structural orientation to concrete praxis as Technology is fundamentally linked to human and social behaviour. Layton (1987:594) sees a moral component as an essential element of the curriculum of Technology Education.
The U.S and Canada approach Technology Education as education about industries. Technology Education is about that part of society's economic sector where products are manufactured. The companies and factories of the industry are those places where the traditional human skills of working with wood, metals and other materials are practised (Fensham 1985:417). Scriven (1987:9), on the other hand sees Technology Education as an "independent science drawing on historical, epistemological, pedagogical and equity grounds for support". This writer goes further by identifying the use, adaptation and evaluation of technologies as the central targets for Technology Education.

Technology Education can be defined under four broad attainment targets according to Fensham (1985:417);

- Identifying needs and opportunities by pupils for design and technological activities by investigating the context of home, school, recreation, community, business and industry;
- generating a design proposal into realistic, appropriate and an achievable design;
- planning and making (by pupils) through identifying, managing and using appropriate resources including both knowledge and processes in order to make an artefact, system or environment; and
- evaluation of the processes, products and effects of the pupil's design and Technology Education activities including those of others
from present and past times and cultures.

Students should be acquainted with technological advancements at an early age as there are abundant types of rules in Technology Education. Students can become facile with Technology Education rules at an early age in ways that lead to critical thinking and creative problem-solving. Curriculum planners and developers towards solving South African Technology Education development restraints can meet these rules.

Technology Education deals with the reality of life. It strives towards equipping students and teachers with skills to find suitable solutions to satisfying real needs and solving real problems, which are embodied in the environment, therefore, preparing students towards the world of work.

According to the author South Africa seems to have a massive problem of inadequate skilled labour and Technology Education, as a subject that prepares students towards an industrial world may be one of the answers in providing South Africa's job market with skilled labour in some or other area. This can be manifested by the very nature of Technology Education through its emphasis on the analysis of problems and needs and the provision of practical, economical and efficient solutions that meet the needs of society and the environment (Nasbilt 1982:27).
The author sums up by stating that Technology Education entails understanding the role of Technology in society and calls for more emphasis in Mathematics and Science on applications in everyday life. Therefore Technology Education refers to learning to learn, learning about Technology, learning to co-operate and learning to create. Therefore, according to the author, the very nature of Technology Education is supportive to Mathematics and Science. The very methods that are used in Technology Education are, according to the author, by nature supportive methods that can be used in Mathematics and Science.

1.2.3 HISTORICAL DEVELOPMENT OF TECHNOLOGY EDUCATION

Technology Education is fully developed in the United States, Canada and the United Kingdom. In America over 30 state industrial education associations had by 1989 changed their names to include Technology Education (Bensen 1989:167). Technology Education dates back to the curriculum reform model of the 1960s, according to Bensen (1989:167) where over 50 curriculum projects in the U.S. proposed alternatives to the traditional wood, metal and drawing content of Industrial Arts.

In the United States the transition from Industrial Arts to Technology Education has been dramatic in the 1980s. Technology Education based programmes appeared and received support in state level curriculum
guides, in local universities, equipment and published material. Some other third world countries such as Taiwan and Israel have done extremely well in establishing Technology Education in schools and universities (Bensen 1989:168).

In Britain in the 1950/1960s the Association for Technology Education in schools and the Institution of the Engineer were pressing for Technology Education in the school curriculum (Fensham 1985:416). This initiative resulted in a curriculum project called Project Technology. The curriculum development for Technology Education in England and Wales seems to be more coherently assigned and detailed than most (Fensham 1985:416). Technology Education in these countries is designated as one of the seven foundation subjects in the curriculum that all students are supposed to study. It is therefore the reason why the status of Technology Education in England and Wales is high (Hales and Snyder 1982:7).

In the 1980s, in the Netherlands the curriculum committee responsible for developing the learning aims and objectives for the new subject Technology Education listed five characteristics as the basic description of Technology Education (Fensham 1985:417) and (De Vries 1988:17);

- it is a human activity for both men and women;
- it involves matter, energy and information as input;
- it is related to Science but conceived very much in physical terms;
• it is a process of designing, making and using products;
• it is also interrelated with society.

According to Ziefuss (1980:35) in Germany Technology Education is characterised by the following perspectives, Technology Education as a subject field and Technology instruction as an independent subject. Although there has been reluctance at an earlier stage to take Technology Education up to the further education and training phase, the following objectives were commonly found in a variety of curricula i.e. practical experience through production of technical instruments, recognition of technological realities, introduction of the forms of thought and problem-solving typical in Technology Education and information facilitating entry into the world of work and individual attention (Ziefuss 1980:35).

Technology Education in Australia is defined as a distinctive component of the core of the general curriculum and it tends to emphasise Science. Technology Education in Australia resulted from the influence of interested people with a strong physics background and people from the technical field (Fensham 1988:380).

Technology Education studies in upper schools were developed by the Senior Secondary Assessment Board of South Australia as a curriculum umbrella within which there are a number of options, each of which is
concerned with the application of knowledge relating to such things as materials, systems, tools and equipment to meet a need or solve practical social problems (SSABSA 1989:19). Technology Education in Australia emphasises the relationship between human needs, human values and Technology, as Technology Education encourages students to use "problem solving techniques and develop skills necessary to be cautious when working with tools" (SSABSA 1989:19).

The exposition above shows the comprehensive nature of Technology Education in all the countries mentioned. As they are more developed than South Africa or are at the same development level as South Africa, the implementation of Technology Education in some of these countries could be used as models for South Africa. Looking at the trends in the above-mentioned countries, the author is convinced that Technology Education is a must in all South African schools. Secondly, it can be a means to enhance performance in Science and Mathematics. Stemming from this discussion the author will discuss the significance of Technology Education.

1.2.4 SIGNIFICANCE OF TECHNOLOGY EDUCATION

It is also important that one mentions the significance of Technology Education in the curriculum. It is imperative for all students to understand
the technological culture as our country is moving in the direction of technological advancement. Johnson (1986:4) believes that Technology Education should be learned so that students as citizens should be able to develop and control technologies so that they can best serve all citizens.

As an example the author is of the opinion that a citizen or future citizen of the country should be able to comprehend the future plan of their towns and cities, understand decisions on the building of the schools and roads as well as environmental care. Technological literacy entails knowledge about maintaining one's personal belongings and decisions on useful purchases (Pucel 1992:333). It entails the making of intelligent decisions relevant to Technology where appropriate.

Technology Education programmes should provide career exploration, as a result Technology Education should provide a basis for work for a large sector of the community. The Technology Education curriculum should cut across the whole spectrum of the technical work from semiskilled up to professional and from trades up to engineering. It should provide students with the knowledge of the requirements for entering, maintaining a competitive edge and advocacy of different vocations in the technological workplace.

According to (Fensham 1988:33) "Technology is needed in schools
provided that it will teach the child wicked effects of much existing Technology and the need for alternatives". Technology is transforming societies all over the world; as a result transportation, manufacturing, communication and agriculture affect our lives. It is therefore essential that the student should understand the world surrounding him/her and give significance to it.

The new social pattern that is emerging includes familiar patterns characterised by divorce, step parenting and income difference resulting in an effect on our lifestyle today. We tend to look at a good product for a reasonable cost. The restructuring of the post office, telephone system (communication) entails new exposure to Technology and the electronic advancement which includes Electronics, Biotechnology, Space Technology, Automation, and which has an impact on our lifestyle. The impact is not only on an ordinary citizen but it is also on the student. Therefore the school, through planning, should give attention to Technology Education.

Television, newspapers and other electronic devices influence the child at home. Curriculum planners should therefore address the curricular implications of this technology-related world of the child in the field of Technology Education development. Technology Education development calls for new skills and transformation of older skills. According to the author Technology Education, by its very nature brings about transformation in
educational practice and truth.

Society is becoming technological, therefore the author is convinced that as a technological society it should be able to provide to students' education which meets the needs of technological transformation in our society and which prepares our students for a future in a technological society. According to Boyer (1983:29) technological literacy is the first priority of Technology Education and therefore places emphasis on the fact that students should be educated about Technology and its relationship to Science and Mathematics.

1.2.5 SUMMARY

Having given the background towards the study of Technology Education the reader can almost deduce what impact it has on the total education system. Technology Education can extend human potential in various ways as explained. It is diversified as it deals with problem analysis and solving, adaptation and need satisfaction. With this in mind one could immediately assess to what an extent Technology Education could enhance performance in Mathematics and Science.

Therefore having the integration of Technology Education, Science and Mathematics cannot only contribute to the total education system, but can
also improve individual performance in Mathematics and Science. This is a means of introducing the statement of the problem to be mentioned hereafter.

1.3.1 GENERAL BACKGROUND

In the previous paragraphs the author discussed in detail the implications of a Technology Education curriculum for South African schools as a means of helping South Africa to compete technologically with other countries as well as a means of enabling South Africans to apply their knowledge to provide solutions to technological problems in this human created world. The author concludes therefore that Technology Education as a means of extending human potential meaningfully by applying knowledge in manipulating and understanding the environment needs to be a school based subject that will instil skills to deal with the technological world at an early age of the child.

It is also evident in the previous paragraphs that the very nature of Technology Education is supportive to performance in Science and Mathematics. As the declining performance in Mathematics and Science is a matter of concern to the author, this link presupposes that Technology Education may enhance performance in Science and Mathematics. Technology Education should therefore be introduced as a means that can
enhance performance in Mathematics and Science. Technology Education teaching strategies as a link to Mathematics and Science presentation should be explored and evaluated for South African conditions.

Furthermore, it will also be of importance that the author should look critically at the delivery level of all these three subjects in an integrated fashion. These problems will be discussed in paragraphs 1.3.2 and 1.3.3.

1.3.2 LACK OF COMPREHENSIVE GUIDELINES

In order to qualify the problem area of the author it is imperative that the author gives a broad overview of Technology and Technology Education. These two areas will serve as a basis upon which guidelines for Technology Education will be provided. Technology will be discussed in Chapter 3.

Stemming from the background given, the problem area of the author centres on four areas.

(i) Firstly, it centres on broad guidelines for teaching Technology Education in the further education and training phase. These are: The Technology Education programme, the role of the teacher in the Technology Education programme and Technology Education
activities;

(ii) Secondly, the author will discuss guidelines for Technology Education teaching strategies;

(iii) Thirdly, the author will explore guidelines for assessment standards in Technology Education;

(iv) Fourthly, the author will also explore guidelines for integrating Technology Education, Science and Mathematics. The author will also evaluate the link between Technology Education, Mathematics and Science.

The author is of the opinion that because South Africa presently lacks guidelines for teaching Technology Education, it is important that all these four expressions be explored. These guidelines will be extensively discussed in Chapter 4.

1.3.3 EMPIRICAL STUDY

The problem area of the author will be qualified by translating Technology Education into the standard 8 classroom in South Africa and evaluating its impact on the academic achievement in Science and Mathematics. This discussion will take place in Chapter 5. This will be done by attempting to give answers to the following questions;
(i) Is the level of academic performance of students in the pilot study who received tuition in Technology Education over a year better than that of students who did not receive tuition in Technology Education over a year?

(ii) Does the inclusion of a Technology Education curriculum in the standard 8 subject package of the pilot study improve the overall performance of these students or not?

(iii) Does the performance in Mathematics and Science of standard 8 students in the pilot study who received tuition in Technology Education improve or not?

The problem area of the author therefore, centres on Technology Education, Science and Mathematics at the further education and training level.

1.4 AIMS OF THE STUDY

The purpose of this study was:

(a) to give the background of Technology Education as a subject and how diverse it is in different countries and to link Technology Education to Technology as its basis;
(b)(i) to formulate broad guidelines for teaching Technology Education in the further education and training phase in general. These guidelines include the role of the teacher in Technology Education, a Technology Education programme and Technology Education activities;

(ii) to formulate broad guidelines for the Technology Education teaching strategies. These Technology Education teaching methods include problem solving, the design process, decision-making, integrative teaching, group and self-activity projects and the use of the Multimedia;

(iii) to formulate guidelines for assessing a Technology Education programme and the translation thereof in the South African context;

(iv) to generate and evaluate a model upon which Science, Mathematics and Technology Education could be presented in an integrated form and to provide an evaluation of this integrated approach;

(c)(1) to compare the level of academic performance of standard 8 students in a pilot study who received tuition in Technology Education with those who did not receive tuition in Technology Education;
(ii) to compare the level of academic performance in December 1993 to those of December 1994 after students in the pilot study have received Technology Education tuition;

(iii) to relate the teaching of Technology Education to Science and Mathematics so as to determine the influence Technology Education has on the performance in Mathematics and Science when comparing the control and the experimental groups in the pilot study.

The following hypotheses and their null hypotheses were generated for the pilot study.

**NULL HYPOTHESIS I**  
There are no statistically significant differences between the mean sub-scale scores for the control group and the experimental group in respect of the Average Examination marks, English marks, Science marks and Mathematics marks, in November 1994. Observed differences are merely incidental.

**HYPOTHESIS I**  
There are statistically significant differences between the mean sub-scale scores for the control group and the experimental group in
respect of the Average Examination marks, English marks, Science marks and Mathematics marks in November 1994.

**NULL HYPOTHESIS 2**

There are no statistically significant differences between the mean sub-scale scores for the experimental group in November 1993 as compared to those in November 1994 in respect of the Average Examination marks, Science marks, English marks and Mathematics marks. Observed differences are merely incidental.

**HYPOTHESIS 2**

There are statistically significant differences between the mean sub-scale score for the experimental group in November 1993 as compared to those in November 1994 in respect of the Average Examination marks, English marks, Science marks and Mathematics marks.

**NULL HYPOTHESIS 3**

The control group sub-scores in the Average Examination mark, English, Mathematics and Science are not the same for the November 1993 as compared to November 1994. Any
observed positive comparison is merely incidental.

**HYPOTHESIS 3**

The control group sub-scores in the Average Examination mark, English, Mathematics and Science are the same for the November 1993 as compared to November 1994.

1.5 METHODS OF RESEARCH

The author will analyse and survey literature of both primary and secondary sources which deals firstly, with Technology and secondly, with Technology Education and thirdly, with the guidelines for teaching Technology Education. An evaluation of the interrelationship between Technology Education, Science and Mathematics will be undertaken.

The author will also explore and evaluate a pilot study to give not only a descriptive analysis of the problem but also to qualify the study with an empirical study of the problem. The empirical study of the trends in the pilot group will be analysed through the statistical methods depicted from Nie, Hull, Jenkins, Steinbrenner and Bent (1975).
1.6 DELIMITATION OF THE STUDY

This study will be confined to the significance of Technology Education as seen in the context of Mathematics and Science, as a driving force and a link to both these subjects. This link will be discussed in chapter four. It is also acknowledged that there may be a number of other factors which can contribute to better performance in Mathematics and Science but the central theme of this study will be based on one of these factors which is Technology Education.

The study will also explore the methods of delivering Technology Education. Technology Education assessment standards will also be explored. Secondly, the study will be confined to the analysis of trends (technological) among the standard 8 students in a pilot study from a Technology College in North Johannesburg in terms of the impact of Technology Education to Science and Mathematics achievement.

1.7 DEFINITION OF TERMS

It is desirable for the author to give definitions of terms to be used in this thesis so that the reader should not have an ambiguous interpretation of the terms as these terms are continuously used in the text.
TECHNOLOGY: It is the application of knowledge, tools and skills to solve problems and extend human capacities. (Johnson 1989:3). It has to do with the design and production of commodities.

TECHNOLOGY EDUCATION: It is a means of empowering individuals by giving them a way or technical resources to control or at least to work efficiently with their environment (Cousins 1981:50). Technology Education has to do with problem solving in which Technology as a tool is used to solve problems.

EDUCATION TECHNOLOGY: It is a means of teaching with Technology. It includes the use of multimedia in teaching.

INTEGRATE: It is an act of integrating parts into a whole. It is the formation of the totality by adding or bringing together all necessary parts.

APPROACH: It is a means to deal with a concept or a means of trying to understand concepts. It suggests closeness almost to the point of
contact, physically or conceptually.

**ENHANCING:**

It is augmenting the existing condition by giving value to or intensifying it. It can also mean to promote and accelerate a condition.

### 1.8 OVERVIEW OF THE CHAPTERS AND PLAN OF STUDY

Chapter 1 will deal with the background and rationale of the study. It also provides developmental trends and significance of Technology Education across the world.

Chapter 2 will deal with Technology as a world phenomenon. It will also deal with developmental trends of Technology in developed countries such as the United States and the United Kingdom. It will also look critically at the impacts of Technology in developing countries including South Africa. It will look at the status of Technology in South Africa.

Chapter 3 will deal with the broad outline of the Technology Education curriculum for the further education and training level. This will be linked with the existing curriculum policy for the Technology 2005 project. It will deal with the focus, scope, demands and aims of Technology Education. Furthermore it will explore technological literacy, Technology Education and
culture. Myths in Technology Education will also be discussed. The Technology 2005 project will also be discussed.

Chapter 4 will explore guidelines for Technology Education. Guidelines for the Technology Education programme will also be discussed. This chapter will also deal with guidelines for the teaching strategies of Technology Education. It will also explore assessment standards for Technology Education. Lastly this chapter will deal with guidelines for assessing the integration of Technology Education, Science and Mathematics.

Chapter 5 will review a pilot study and the statistical analysis of Technology Education trends with regard to the experimental and the control group, will be undertaken as a significant means for justifying the importance of Technology Education towards enhancing academic performance in Mathematics and Science.

Summary, findings, conclusions, implications, recommendations and limitations of the study will be presented in Chapter 6.
CHAPTER 2 - TECHNOLOGY

2.1 INTRODUCTION TO TECHNOLOGY

Technology is the "application of knowledge, tools and skills to solve problems and extend human capacities." (Johnson 1989:3). Technology is best described as a process but it is commonly known by its products and effects on society (Johnson 1989:3). Technology is both a technical and a social process. It is enhanced by the "discoveries of Science and shaped by the designs of engineers" (Johnson 1992:3). Technology is conceived by inventors and planners, raised to function by the work of entrepreneurs and implemented and used by society.

According to Larkin (1992:23) Technology is a "body of knowledge and actions about applying resources, developing, producing, using and assessing, and extending the human potential, controlling and modifying the environments". Technology is designing things, making things, doing things and it is introducing those things into society. Technology is the action part of the technical world, guided by various values of society it serves.

"Technology is so deeply intertwined throughout people's lives that it is sometimes hard to recognise because of its pervasive nature. People become dependent upon their technologically modified environment for their
basic life support needs for food, clothing, and shelter as they become detached from their natural environment” (Ortega and Ortega 1995:35).

Technology is a system and its major activities are developing, producing, using and assessing (Johnson 1989:48). These technological activities are universal for all technologies. They can be defined from the applied Science approach of physical, bio-related and Information Technology, the resources approach of information, energy and material and the human productive activity approach of communication, construction, manufacturing and transportation (Ibid:48).

Technology can also be defined in terms of societal applications. It can be applied by an individual in an avocation or charitable setting or by an economically driven group. Technology can also be viewed as a system with identified basic components, such as designing, producing and using products.

All technological artifacts result from human volition created as a need or as a desire to be possessed (Larkin 1992:23). According to Larkin (1992:23) responsible development and use of Technology moves through a three phase approach involving three separate systems:

- the designing system;
- the production system; and
- the consumption or application system.
Advancing Technology has influenced our lives in many ways. Telecommunications and satellites have provided us with immediate awareness of global issues. Modern transport systems have made the world more accessible (Larkin 1992:23). Improvements in household appliances have provided more time to pursue personal interests. These changes have also had social, economic, political and educational implications (Ibid:23). The changing nature of our technological society is placing new demands on the society (Ballistreri 1987:3).

In summing up, the author defines Technology as a process in which human capacities, tools, knowledge, skills and other resources are used in controlling the environment by designing, producing and applying commodities to real life situations. As mentioned earlier that Technology is a universal concept with global applications, the author will explore the status of Technology in developed and developing countries including South Africa.

2.2 TECHNOLOGY IN DEVELOPED COUNTRIES

Europe, United States and Japan believe in extending their domestic base and global economy growth and development. This is undertaken through embarking on a "Triadic approach which is the strengthening of their domestic base and designing and implementing a global common development with each other" (Petrella 1989:401).
The Triadic approach is based on the idea that in order to remain competitive, any global or internationally oriented form of economy has to be present simultaneously in the three most developed areas of the world i.e. United States, Europe and Japan, which represent the world's largest solvent and increasingly integrated market. The triadic development does not exclude the future emergence within the triad of hidden forms of technonationalism and technological patriotism (Petrella 1989:401). The author will discuss the technology development trends in each of the three countries, which embark on a Triadic approach.

The United States is perceived to be on the leading edge in biotechnology, electronic systems and software (Perrino and Tipping 1991:90). The United States has not only concentrated on internal development but has also tended to support major new business thrust by setting overseas laboratories staffed with her own people. There has also been an upsurge in business for supporting research in the United States. Companies are also becoming much more creative in how they use academic resources. United States firms fund universities in order to build credibility and a base for expansion. Even the United States national defence and space programs are the source of leading edge Technology in many universities from small to advanced composites. Through Technology Education the expansion of Technology has also been supported from elementary to high school (Perrino and Tipping 1991:90).
Competition for emerging markets and technological leadership is not new in the United States, what is new however is the intensity and globalisation of that competition. Technology development is accelerating in the United States, receiving the stakes and penalties for managing innovation and requiring early ways and a shorter response time to capture opportunities both in the United States and the outer markets.

Specialisation and systems requirements are both increasingly driving a growing need for integrating people and disciplines and integrating critical skills from wherever available. Newer technologies are rapidly becoming pervasive, redefining competitive value across a broad range of traditional markets and spanning major emerging growth markets.

In Europe Technology is increasingly acquiring a strategic relevance for political independence, economic development and social welfare. Europe is strategizing for technological development, aims towards revitalisation and reorganisation of high technology sectors in a more united way, with a view to avoiding overdependence on foreign technology and to survive the global battle for technological supremacy brought about by the United States and Japan (Petrella 1989:401). European perspective takes as its important key the European technological co-operation.

Strengthening of domestic Europe is characterised by the idea that the future of a firm including a global firm, is closely linked to the existence of a
strong domestic base. Giving priority to the strengthening of a domestic Europe in an open economy would be favourable both to less developed regions and to small countries in Europe. The absence of large internal markets and the weakness of European common endeavours limit the possibilities for European firms to develop strategic capabilities as strong as those of their world competitors do.

Global common development is based on the understanding that in the year 2020 the world’s population will reach around 7.2 billion, 5.1 billion of whom will be in tropical and subtropical regions. It is assumed that the present forms of maldevelopment and misutilization of natural and human based services are gaining such momentum and becoming so structural in character that if a global common development strategy is not adopted the whole system is at great risk (Petrella 1989:402).

Finally Europe has a distinctive competence in software and is doing well in telecommunications and chemicals. European companies have been most aggressive in promoting Technology in other countries through the acquisition of entire companies.

Japan holds the power on consumer electronics, semiconductors, and low cost manufacturing technologies and a few other areas. Japanese companies rely heavily on home production, scale and product development
to build their markets and have acquired Technology rather than establishing ties overseas.

Japanese increase their overall spending by restructuring their domestic base through the formation of strategic alliances between companies and encouraging technological clusters of companies and universities (Petrella 1989:402). Japanese establish their own Technology research laboratories and strategic interaction alliances and also rely on their traditional listening approach. While costs per employee, both expenses and capital, differ from industry to industry, all industries show decreasing cost trends with increasing laboratory size.

The growing need for closer interaction with customers and markets is worth noting, in Japan especially, in areas like aerospace composites and structural ceramics and businesses that are extremely applications oriented or whose customer tailored technologies are pivotal. Therefore Japanese companies favour a mode of acquiring and sharing Technology (Perrino and Tipping 1991:93).

Japan like Europe and the United States believes that in order for her to remain competitive she should compete internationally with Europe and the United States (Triadic approach). Japan also believes in strengthening herself and aiming at the global common development.
Technology is the key factor in national survival. As a result managers in the United States, Europe and Japan overwhelmingly rank leveraging of Technology for competitive advantage "the primary challenge the companies face" (Perrino and Tipping 1991:87). Technology is one of the key competitive tools in today's market place. The United States, Japan and Europe believe that the skilful management and deployment of Technology is more important than the technological resources themselves.

New technologies and the specialised talents that produce them will continue to develop locally in products of innovation around the world and global Technology development is a challenge in Technology management. The United States, Europe and Japan companies are pursuing outright in their home countries a proactive programme to initiate products of expertise and identifying leading edge talents.

Participating in consortia and joint ventures helps the United States, Europe and Japan to develop a global Technology management programme that concentrates on gaining continual access to evolving technologies. For companies to be successful they should give priority to effective communications and the integration of resources. Implementation of a global Technology network should be a long-term process that demands commitment. Japan, United States and Europe manage this commitment in a co-ordinated way for maximum impact.
Japan, Europe and the United States seem to be the utopia in Technology development. As South Africa is not at par with these three countries and is a developing country, it is of importance that South Africa be viewed as a developing country. The author will therefore discuss the state of Technology development in a developing country milieu.

2.3 TECHNOLOGY AND DEVELOPING COUNTRIES

The different developing countries are presented with generic technologies at different times, at different stages of the development of their economies as well as at different stages of a global socio-economic system. For developing countries to be successful in Technology development these countries should subscribe to the following ideas.

Firstly, developing countries should monitor outside developments in Technology thinking, innovation and application. These countries should receive, select and disseminate relevant technological knowledge needed for conducting technological assessment. Secondly, developing countries should ensure ongoing information exchange, concentrated planning and collaborative implementation among categories of natural sectors i.e. government decision-makers, economic procedures and technological researches. This can be manifested through the use of Technology futures and processes, Technology innovation, planning theory and innovation process in Technology development.
2.3.1 TECHNOLOGY FUTURES AND PROCESSES

Technology futures and processes, also known as Technology forecasting and processes, are characterised by Technology monitoring. Technology monitoring is not and should not be limited to identifying the tendencies of technological performance coefficients for the purpose of projecting future trends. It is also undertaken to deal with the present Technology trends. Technology must be analysed from the perspective of the innovation process as involving economic production systems, Science and Technology systems, and the non-linear interaction of the two (McLoughlin and Clarke 1988:201).

Impact assessment as part of Technology forecasting is bi-directional, involving not only the social and economic impacts of Technology but also futuristic impacts on Technology. The Technological innovation process is an extraordinarily powerful instrument for change, if it is understood and managed properly. Innovation is a two way process, it transcends from Scientific and Technological change to social change and from social value to Technological value. Therefore both should be assessed (Clarke 1990:21).

The government sectors, enterprises, institutions and other vested organisations and people should be used in the development of Technology forecasting and processes. This duty should not be solely given to the
government as it can be contaminated with politics and might be rejected by the new government if any.

General concepts of technological innovation and planning theory cannot be attached to a standard prescriptive methodology. Each Technology forecasting and innovation planning is unique and distinct and as such each requires a separate methodological development. "The development of individual and institutional capability for Technology futures and innovation process planning is best accomplished through experience" (Johnson and Maccovitch 1994:27).

Problem analysis, selection and formulation reinforce the innovative process. Planning is therefore integration related to decision-making actions and evaluation. It is important to also note that a process highly dependent on decision-makers has problems for Technology forecasting and process planning, as Technology forecasting and process planning is characterised by an element of dynamics. It is also important to note that not all problems require an innovative process approach. The normative strategies and operational levels can be used for complex problems and conventional Techno-economic analysis and traditional planning techniques can be used for simple range, isolated problems. The Technology futures and process planning is complex and risk-laden especially in the function of the wide scope, methodological difficulties and in the need for multi-perspectives and participation.
The active participation in and promotion of Technology forecasting and process planning by government, including divagation, financing and sponsorship evidently facilitates its adoption by other agents and should be encouraged (Johnson 1994:29). Noting that the scope, difficulty and cost of Technology forecasting and process planning determine obstacles and create parameters with regard to users, small organisations would therefore find it difficult to justify necessary investment and added cost although techniques are continually evolving.

By definition the planning process occurs within the context of a single agent or institution, and the absence of structures and traditions of communication and co-operation among the various agents and institutions can create difficulties either in problem formulation or necessary participation. These structural or normative strategic operational planning processes need a multi-institutional, multilevel involvement and participation.

2.3.2 TECHNOLOGY INNOVATION

The importance of innovative processes and Technology futures is enhanced by radical changes in the relation of the world in the geopolitical and economic spheres (Johnson and Marcovitch 1994:2). New Scientific and Technological paradigms are incorporated in the productive sector innovation for optimum productivity.
Innovation comes as a result of an interaction between the economic production system (technology users) and the Scientific and Technological community (Mole and Elliot 1987:400). This innovation process focuses on the innovation concept resulting from the need or opportunity identification in the production system and the technical means identified in the Scientific and the Technological area. Technological research is undertaken or available Technology is utilised and Technological development and engineering are undertaken to come to a Technological solution which is incorporated in the economic production system and innovation.

According to the author there can be no doubt that the promotion of Technological innovation is judged internationally to be an important priority of national government. Areas such as Information Technology, Biotechnology and new Engineering material have become the focus of national programmes intended to boost competitiveness and create long-term employment (Irwin 1989:47). Technological innovation is the way in which organisation control and change Technological skills (McLoughlin and Clarke 1988:202).

It is of paramount importance that one should understand the sources, actors and sequences to Technological innovation that permit more effective planning and management. It is also important to understand barriers to effective planning and management. There are three features of paramount
importance that need clarification and understanding. Firstly Technological evaluation as measured by qualitative Techno-economic performance indicators, presents highly stable rates of growth over long periods of time. This characteristic forms the basis for numerous Technology forecasting techniques (Bright 1968:29), which statistically identify historic trends and extrapolate future performance often with surprisingly accurate results. New basic technologies or new paradigms involve much experimentation, many new and small firms, more open areas to and transfer of information about new Technology therefore extrapolate Technology forecasting techniques are unable to predict new paradigms and transitions to new basic technologies. These can only be done by Technology monitoring techniques being in time to permit Technological and industrial policies that favour investment and growth.

Secondly there is an interdependence of Technological development i.e. research, development engineering with characteristics and conditions of the economic production system. This implies that Technological development is a problem solving tool for economic production.

Innovation may also result from the advance of scientific or technological knowledge called technology push in which technical advances must encounter problems or opportunities in the production system to which they can be applied in order to be incorporated in innovations. On the other hand
stable technological performance trends are primarily the result of a relatively constant market pull process, in search of lower costs and better quality with regard to raw materials, process and product characteristics (Mole and Elliot 1987:400).

Lastly basic Technology will change as a result of significant scientific or technical knowledge, creating new technological paradigms. Technology futures are therefore essential elements for planning and managing technological innovation although their role together with innovation planning and managing is differentiated according to the scope or level of the innovation problem.

2.3.3 PLANNING THEORY

For planning to be understood it is important for the author to give a description of both traditional planning and prospective comparison, as the results of planning can be both indicative and directional depending on a problem at hand. Planning is therefore a distinct adjunct to decision making through the systematic enrichment of the information base for decision-making (Jantsh 1969:29).

Traditional planning can be conceived as essentially Techno-economic analysis, which precedes or is parallel with decisions. It is an anticipating
decision as to what should be done (Newcomer 1959:15). Traditional Tele­
economics planning deals primarily with controllable variables of possible solutions but treats other factors as premises or externalities wherein objectives are given. Traditional planning is effective for short term, deterministic evolution of well defined, highly structured problems.

Prospective planning on the other hand looks ahead to better understanding the future with emphasis on the external context or uncontrollable factors. Through assessment of future consequences, of current action alternatives and by understanding the present action implications of alternative future objects, enrichment is accomplished. Prospective planning is characterised by the "future alternative scenarios requiring multidisciplinary approaches that determine and describe the future. Prospective planning strategies are needed for long-term complex problems in which both objectives and solutions are open to question" (Johnson and Marcovitch 1994:9).

Traditional planning has defined the elements of planning as means and ends, or actions and objectives. Complex long-term planning requires the examination of external factors according to prospective planning. Planning is therefore extended to form essential elements of resources, actions, objectives and content and these elements are interrelated with the aim of obtaining consistency, coherence and equilibrium.

Traditional planning takes objectives as given, concentrating on evaluating alternative actions in terms of efficiency in order to obtain effective allocation
of resources, whilst prospective planning amplifies the scope of analysis to include normative factors through systematic examination of the context to enrich information for decision making.

In examining the dimensions of the future for planning, Johnson and Marcovitch (1994:9-10) discuss three orthogonal dimensions of the future relevant to planning. The first dimension is the predictive that deals with the question of where we are going as a result of current trends. For the accomplishment of this dimension essentially qualitative information on Techno-economic coefficients is necessary. This information is provided by predictive methods of extrapolation such as econometrics, time series, envelope cues, historic analogies, and substitution analysis. Through these methods historical trends are projected into the future. Therefore this dimension projects the future by identifying future problems and projecting external factors.

The second dimension called the exploratory dimension, deals with what is possible in the future as related to what can change now. The future is explored so as to detect opportunities and threats to identify and evaluate alternative objectives and alternative strategies as well as to introduce and deal with uncertainty in the planning process. Different methods are applied to explore the future. These are matrixes, structural modelling, morphology, modelling system analysis and dynamics, delphi and alternative scenarios.
These methods are applied to provide both qualitative and quantitative information about the possible impacts of a technological trend on the future.

The third dimension concerns where a country ought to or wants to go. Normative methods which are the same as used above are applied to issues of social value and the relations and negotiation of power in relating the planning question to its relevant context. Lastly planning in Technology advances can either be concerned with defining future states within the national policy planning (normative planning) or be essentially a process for integrating ends and means as a necessity for both structural applications and for enterprises and institutions (strategic planning). Planning can also be concerned with means and be applied at the enterprise/institution and as action unit aggregates (operational planning).

2.3.4 INNOVATION PROCESS IN TECHNOLOGY DEVELOPMENT

The innovation process is the prescriptive sequence of activities, which produces innovation, and it is characterised by six distinct activities (Jantsh 1972:48). These are prospecting, modelling, traditional Techno-economic analysis of alternatives, decision making, action and evaluation and control.

The innovation process presents significant methodological differences depending on the nature of the planning problem in question. The author will
also discuss three planning problem types and link them with the innovation process as characterised by the six activities already mentioned.

If the problem is a national level policy problem, innovative planning is strongly normative in nature and emphasis is on the value laden definition of desired future states. The utility emphasis of the process is on normative prospecting which provides qualitative and quantitative trends for solving the problem. Modelling deals with the analysis of the production system interaction and impacts on the relevant context under different rules and norms. Techno-economic analysis becomes minimum, primarily directed to prefeasibility. Decision-making deals with the definition of normative legislation and regulation. Actions become institutionalisation or structuring of the production system and it ties to the context, the allocation of the functions and missions to the institutions and organisations in the structure and the enforcement of norms. Lastly evaluation will be directed to monitoring and assessing the policy and focusing on the effectiveness of the system structure and regulation with regard to the context.

In case the problem is based on action unit planning programmes and projects, the innovation process becomes operational planning concerned with resource restructured actions with a short to medium term future. The prospecting activity will likely be used to optimise time and resource use. Techno-economic analysis is likely to indicate the most cost-effective action
alternative while decision making will result in the selection of the desired action alternative constituting programmes and projects with corresponding goals and budget. Action will consist of programme/project implementation and evaluation will provide control based on the criterion of efficient resource use.

Lastly, if the problem is structural or institutional the emphasis will be on a strategy as an integrative factor in order to ensure continuity, prosperity and growth. Through prospection, the context to identify opportunities and threats will be analysed and modelling will be represented by strategic analysis of strengths and weaknesses, opportunities and threats. Techno-economic analysis is a vital assurance of the economic basis of enterprises, as the gauge of the efficiency and effectiveness of the enterprise in production strategy selection, objective setting, prioritisation and resource allocation will be indicative of decision making and actions will concentrate on organisation capacitation in order to assume attainment of objectives. Through feedback control for efficiency and effectiveness evaluation is undertaken.

2.4 THE ACQUISITION OF TECHNOLOGY BY DEVELOPING COUNTRIES

The acquisition of Technology by developing countries depends on the type of Technology made available. In a bid to understand Technology in a
developing country milieu it is important that one becomes aware of different generic (basic) technologies available in the world and the different ways in which Technology interacts in a developing country milieu (Goonatilake 1994:63). These generic (basic) technologies go through industrial economy in "constructive ways of destruction, destroying the old and establishing the new" (Schumpeter 1939:18). They are established as a means by which old technologies are replaced. Thereby new technical means of manufacture, with a new range of products are established. Various technologies developed over time such as steam, electricity, chemicals, oil based chemicals and synthetic materials are modified further. Recently two technologies are rapidly maturing. These are Information Technology and Biotechnology and these are likely to penetrate the economy intensively. They are more generic than other old technologies.

As earlier mentioned, different developing countries are presented with different generic technologies at different times, at different stages of the development of their economies as well as at different stages of the global socio-economic system, and they are presented in a more telescoped form, all clustered more or less together (Baghi 1987:52).

These different generic technologies bring about certain impacts to developing countries. They result in the reproduction at a micro level of social relations derived from the society that acquired Technology (Heyzer
These generic technologies are normally products of social changes within certain countries and they simply act as a carrier of particular social relation. They reproduce some of the social relations of society that gave birth to it (Goonatilake 1978:7). As these are not just inanimate objects, they change in response to implicit or overt socio-economic changes. They are the products of social and technical factors. Acquired Technology affects gender equality, environment, ethics, infrastructure and social structure at various levels of intensity. These will be discussed later.

2.4.1 TECHNOLOGY AND GENDER

A gender dimension accompanies the social aspects of Technology. Major technology developments seem to marginalize women through different ways in which technology is packaged and introduced. Inherent features of technology restrain women. They are masculine in nature. For instance, in certain laboratories not only reasoning skills are required but also masculinity to undertake certain jobs. According to Heyzer (1988:61) recent industrialisation also brought about negative gender impacts. "Information Technology to a certain extent has gender biases in the sense that its content is characterised by disciplinary assumptions" (Kaplinsky 1987:29).

These disciplinary assumptions suggest a masculinization, which ignores alternative constructions of feminine reality. Gender bias against women
also exists in current computer software whereby cultural factors, including gender relations, influence Technology (Kramer and Lehman 1990:21). This trend is being evaluated gradually by the women's rights movements to show their capability in the world of Technology. It is important that developing countries should be aware that acquired Technology can promote gender inequality. Therefore acquired Technology should be carefully scrutinised in this regard.

2.4.2 TECHNOLOGY AND THE ENVIRONMENT

Generic technologies also have an impact on the environment and pollution. The production process impacts on raw materials, energy needs, the nature of waste products and the generation of heat. Although older technologies have more impact on the environment, new technologies such as Biotechnology also add an increased stress on the biosphere such as ending biodiversity through the introduction of mono cultures of the most productive plants (Sercovich and Morin 1991:84).

Inherent organisational features of the western technologies should not necessarily be replicated when adopted in a developing country as these inherent factors will have detrimental effects in Technological successes or failures in developing countries. Technological productivity will not be optimal in the case of the transfer of Technology that is associated with a
particular organisational structure in a developing country with a totally different organisational structure, or a culture milieu with different organisational structure forms and motivation factors.

The development of new technologies has changed the organisational face of acceptable industrial technologies. The new technologies have made the economics of small scale manufacturing in some technologies desirable. Adoption of new organisational forms by developing countries could have an added effect on the macro-social impact of Technology and result in a separation between those who plan and those who follow orders in the manufacturing phase (Bendix 1963:31). Developing countries should be aware of new technologies to be developed and new organisation forms available to be adopted.

2.4.3 TECHNOLOGY AND ETHICS

New technologies pose ethical dilemmas of a unique nature that have yet to be considered in the developing world to prevent undesirable aspects of Technology coming in unexamined (Corder 1986:4). Different technologies, especially new technologies, may or may not be the answer to local questions of some of the troubling and value questions, as a result most developed countries are not likely to warn developing countries about the effects of these technologies on culture and values. The reason being that other developed countries would like to benefit economically by selling these
technologies to developing countries.

Examples of these dilemmas could be given when Biotechnology today could reshape and reformulate among others life, death, health and beauty (Beree 1990:58). On the other hand Information Technology aims at attending to the concept of the partial behaviour of the mind as a result Information Technology is questionable to developing countries that have strong cultural and religious traditions that emphasise the importance of the mind and mind culture.

It is therefore important that Biotechnology and Information Technology should be mapped within the society's values and culture so as to allow for the consumer's social intervention in Technology and not the implicit intervention that usually happens when Technology is transferred. Technology should then reflect the best social aspirations and knowledge systems of the different cultures and values of developing countries.

2.4.4 TECHNOLOGY AND INFRASTRUCTURE

Existing Technology infrastructure in developing countries makes it possible for new Technology to be transferred thus allowing new technologies to blend with old Industrial technologies (Bhalla 1984:17). Some of the old technologies link to new technologies. Knowledge in developing countries
can be used or refined to be used in both Biotechnology and Information Technology. In adopting new technologies developing countries should be aware of its link with local Technology.

Informal sectors are responsive to immediate market demands and these market opportunities use knowledge and Technology wherever it is opportune and wherever it finds it (Goonatilake 1994:73). Because of the constant innovation in informal sectors, it is likely that new technologies can be transferred with ease in informal sectors. It appears it is in the informal sector milieu that almost real technology creativity takes place.

The creative interface of the informal sector and technology is vital as the informal sector and its technology constitute a significant part of a developing countries' economic life. In a more developed country such as Japan, the boundary between the formal sector and the informal sector with regard to organisation is minimal, as a result a positive milieu for organised Technology development is created (Takaweza 1969:178).

2.4.5 TECHNOLOGY AND SOCIAL STRUCTURE

For developing countries, acquisition of Technology should be seen as an ongoing process that should be institutionalised. Institutionalisation makes the acquisition of Technology legitimate as it includes identifying Technology
services in developing countries and identifying niches for the countries' industrial products. Technology acquisition should reflect the dynamic underlying reality outside a narrow spectrum.

There are many variables that impinge on Technology in developing countries. These variables are brought into the social and ethical domains by the new technologies of Information Technology and Biotechnology. Technology acquisition cannot be seen as just a transfer of concepts developed elsewhere that benefit the West, it should be seen as a part of a broader societal dialogue.

In Technology acquisition potential stakeholders in developing countries should be consulted. Their views should reach the technological and economic decision-makers. One should also note that in many developing countries various scientific and technology fields have been mapped out only partially as interacting with other disciplines (Goonatilake 1994:97). As a result fractural perceptions in various groups cannot reach decision-makers in Technology. Attention should be given to fully integrating Science and Technology into other fields.

The general debate on Technology and decision making in developing countries has been restricted to a narrow social state. As a result those who introduce Technology and filter it in an economic sense into the country
generally do not consider the possibilities of looking critically at the contents of this Technology. In developing countries a more active concern is how to generate Technology in a society and how to bring its introduction into most debates on development. Therefore Technology forecasting is used for this strategic planning.

Finally when considering key aspects of dealing with Technology and the environment, the existing economic sectors including the informal ones, organisation forms, local knowledge and gender relations need to be described. The boundary into multifaced discussions on industrialisation policy often has to be chosen (Goonatilake 1994:75).

2.5 IMPORTING TECHNOLOGY

In most African countries and other Technologically underdeveloped countries the policy of Technological development is based on imports. This is caused by the fact that most of these countries have inadequate creative or adaptive capacities for pursuing an autonomous policy in Technological development. Universities in general are seen as establishments that play a role in the creation and dissemination of simple Technology but most are not adequately equipped for designing, assimilating and disseminating Technology.
Furthermore the new Technology imported into the system creates a qualitative and quantitative imbalance between supply and demand on the labour market and between training needs and the resources of the educational system. Imported Technology is coupled by qualitative and quantitative objectives. In developing countries importation of Technology is directed towards promoting economic trends without too much concern about mastering technologies which is underpinning that growth (Kone 1984:518).

Such direction develops private sectors and increases the efficiency of production and the level of qualification for workers. The concern is more on the number and the quality of commodities produced and not understanding the Technology forming the basis for that production. Such concerns develop private sectors and increase the efficiency of production. The level of qualification for workers can only improve if opportunities for training are also provided.

Imported types of Technology modify the structure of employment directly through the activities of the design and planning offices of transnational corporations in developed countries without any interest on the part of the vocational education and training system in an importing country. In order to meet manpower requirements resulting from the introduction of new
production techniques and new methods of organisation the education system responds by training the necessary staff.

Importation of Technology is coupled with capital investment, the type of Technology used, and the skilled staff coming from outside the country, the dichotomy between production and the education system and from the limited place allotted to the teaching of Science and Technology in the system of education and training as a whole (Kone 1984:509). These factors have to be addressed when considering importing Technology.

Human and economic factors play a role in the process of mastering changes that occur in Technology. As a result countries develop open policies towards other countries as a means of inventing new technologies to enhance the development of the country. In most cases importing Technology results in foreign staff taking control of the methods of work and modes of organisation, the manufacturing techniques for making new products and the operation of the machines engaged in mass production.

Because the whole process of importing Technology may result in substitution industrialisation whereby private individuals and industrial enterprises from developed countries bring in their own skilled labour in the building of features and branches of firms in developing countries. This can only be alleviated if developing countries could send their personnel abroad
to assimilate new types of Technology used in the host country so as to win back and contribute to the economic growth in their country of origin. These nationals would then develop with regard to particular technologies rather than developed countries coming in with their own personnel.

Imported Technology influences the structures of production and training in different ways. This depends upon the socio-economic conditions in each country. In countries with adequate means of assimilating such Technology and an education system with an intensive research component, and where the mastery of imported Technology forms part of a clear cut policy under which adequate means of achieving that mastery have been made, Technology can be assimilated with ease. The education system may be able to make a significant contribution to the dissemination of new methods of production and organisation, which modify economic and employment patterns (Kone 1984:511).

This is difficult in countries that do not have the capacity to adopt or modify imported Technology, especially where research activity is scanty and where little integration of research and teaching is undertaken. In most cases and in most of the developing countries, importing Technology is a must whether in the organisation of production and the work process, the designing of industrial equipment or the developing of new products. In most cases local personnel adapt themselves to imported Technology.
In most countries importing Technology is like inviting a foreign system that upsets the natural order of things in the system, which imported Technology, invades. The changed employment patterns and new needs on training and development bring this about. Such an import could also be an advantage to the provision of work for both participant and training personnel.

Without a doubt the importation of Technology is likely to continue. Manpower should be made available to adapt and assimilate imported Technology and to design and produce new Technology. It is also important for the developing countries to give priority to Scientific and Technological education so as to empower its citizens to research and produce their own technologies. More emphasis should be placed on research as research findings can be put to use in production and help to improve the standard of education. In developing countries creativity and innovation must be developed in all educational establishments even at the lowest level, so as to ultimately contribute towards the generation of their own technology.

Through these actions the developing country will circumvent the use of a policy based only on imported technology. Instead the developing country should build its financial muscle, develop its natural resources and train its personnel to develop a technological programme of its own. National design and research facilities should be strengthened both inside and outside universities to facilitate generating its own technology. The developing coun-
tries should adopt an educational policy that will take local conditions into account and include a design and research component at its education institutions which will help these countries to design and implement a rigorous and appropriate policy for technological development.

2.6 INTERNATIONAL COMPETITION

2.6.1 GENERAL OVERVIEW

International competitiveness depends on the vertical cohesion of, among other things, elevated competition, and improved quality of products and services. The globalisation of emerging markets and technologies and the privatisation of production are world tendencies that explain the interest of government and enterprise in the question of international competitiveness. This competitiveness is increasingly dependent on a new product paradigm in which Technology plays a role.

According to Hemming and Hemming (1992:311) international competitiveness is evidenced by four areas. Firstly, production efficiency is measured by the extent to which production utilises resources in providing goods and services of high quality at a low cost. Competition is obtained within the context of a national economy and describes the capacity of a nation to sustain or increase the participation of its goods and services in international markets, while at the same time the nation must increase the
quality of life of its population by internalising the competitive economic advantage in social gain.

Secondly, international competitiveness is determined by the extent to which innovative enterprises control production, develop and incorporate Technological innovation and place products and services in a high competitive world market. A competitive nation should stimulate components of the national context to gather enterprise efficiency and social justice. This is done so as to improve production efficiency at national level.

Thirdly, international competitiveness is determined by the nature of the economy that establishes fundamental characteristics of co-operation among downstream and upstream competitive sector components and competition within each stage of the production chain. Technology development seems to be imperative if advanced companies are to survive more so than Technology based companies (Hemming and Hemming 1992:311).

Lastly, the fourth area deals with general conditions governing production at the macro-economic and social context. A competitive enterprise has the capacity to obtain and sustain elevated standards of efficiency in the use of resources and efficiency in terms of quality and consumer expectation at enterprise level. Technology knowledge becomes even more vital as the
The time gap from scientific invention or innovation to application or widespread adoption steadily increases, as a result international competitiveness should be able to anticipate, produce and deliver products and services at lower costs.

Competitiveness therefore reflects the capacity of the economic sectors to generate and develop advantages that sustain a high level of international competitiveness. The innovation process should be directed to strategic opportunity, intersectional co-operation and competition.

2.6.2 COMPETITION IN DEVELOPING COUNTRIES

The success of an enterprise is manifested in attaining a competitive position that gives superior performance, and according to Porter (1990:18) there are three stages of advancement in international competition, namely:

- basic factors of production driven competition;
- investment driven competition and;
- advanced factor based innovation driven competition.

A coherent Technology strategy is essential in order to expand and diversify the industrial base of a developing country and to increase the competitiveness of its exports (Sharif 1994:157).
Technology strategies of an enterprise in developing countries should, according to Sharif (1994:157) change over time coinciding with the different stages of industrialisation and for different stages in the life cycle as follows:

- Stage 1 - imported and old Technology-based small and medium scale enterprises for low-value local market

- Stage 2 - selective importation of Technology mostly through joint ventures by medium-size firms and

- Stage 3 - creative invention based on licensed Technology enabling large firms to enter the international market

- Stage 4 - introducing self-developing technologies giving rise to temporary monopolies in emerging areas

The proven path for strategic progression in the context of developing countries is from technology extender to technology follower and then to technology leader. This desired progression can be achieved through the allocation of adequate resources for technology capability development infrastructure and to promote a better technology climate (Enos 1990:37). It
is a progression, as it shows how a country develops from a level of extending existing technologies to a level of generating its own technologies.

Technology extenders cater for the low value price sensitive markets, which have been vacated by the industry leaders. This enables production technologies, which are suitable for adoption to be readily transferable to the developing countries. Companies take advantage of the cost factor in price-sensitive markets and fill the gap created by industry's giants shifting to emerging areas, price leadership, Technology components, and this results in the creation of secondary technology capability (Clark 1989:95).

Companies simply extend existing technologies.

Technology followers can reap benefits if they could buy state of the art facilities or modify products and processes through reverse engineering. They need to be good at quickly adapting advanced technologies to join the high value market in the beginning of the growth phase of the product life cycle (Sharif 1994:167). Advanced Technology capability is needed for international companies to adapt and use advanced technologies for growing regional and global markets, niche and quality leadership, high value markets and to buy and make technology components (Fusfeld 1989:604).

Market growth enhances a rapid growth in technology and may be brought
about by the exploitation of standardised technologies. The exploiter strategy cannot be sustained unless the infrastructure is built to move into the follower and then the leader strategy in selected areas (Porter 1990:19). Adequate Technology infrastructure is needed by international companies who use the advantage of production factor costs and market differentiation, utilising standardised technologies, general price leadership in the medium value market, buying available Technology components and in the need for secondary technology capability (Pavitt 1990:25).

The Technology leader strategy entails the use of state of the art technologies by pioneering companies. The state of the art technologies are used for competing in growing global markets, niche and image leadership and very large value markets. They are used where there is a demand for a sophisticated, accelerated quality improvement and for making advanced and specialised technology components, which have a superior technological capability. The Technological progression pattern from extender to exploiter to follower to leader does reflect a process of industrial restructuring broadly determined by competitive market forces. At the beginning stage a developing country is almost entirely dependent on imported mature technologies to take advantage of relative abundant endowment of either natural resources or unskilled labour or both. It is at this
stage that local companies involve principally the effective operation of simple imported technologies.

Although all firms need not be able to engage in major product and process innovation, they must at least have the capacity to undertake incremental improvements in existing technologies as competition is increasingly based on product differentiation and value addition (Sharif 1994:162). The follower strategy requires a large number of scientists and engineers. The leadership strategy requires innovative capability and entrepreneurship.

2.7 SUMMARY

Technology is rationally applied to problem solving with a view to exercising control over nature, human behaviour and social institution. Technology is a system of means at the service of the larger human ends, in reality and it tends to displace ends and impose it as a self-validating system of means (Goulet 1989:48).

Looking at the nature and scope of Technology, its development in America, Japan and Europe one tends to understand why developing countries should yearn towards Technological development. Developing countries are presented with generic technologies at different times and different stages of development. These countries should adopt and adapt these technologies to
their local conditions. The same should apply to South Africa as a developing country.

Importing Technology entails gearing the country towards the promotion of economic growth by increasing efficiency and capital investment. Training conditions and facilities should be a receptive means to imported Technology. There should also be means towards inventing own Technology.

Finally, South Africa as a developing country, should be able to offer competitive Technology innovation. This may only be done through the provision of an education system that supports Science, Mathematics and Technology Education.
CHAPTER 3 - TECHNOLOGY EDUCATION

3.1 FOCUS ON TECHNOLOGY EDUCATION

Technology is a "conscious process by which people alter their environment" (Ortega and Ortega 1995:34). Technology provides a balance between concrete and conceptual knowledge of issues (Salinger 1996:38). The technological environment shapes and influences lives to such a great extent that an awareness of the impacts of Technology on people's lives, society and natural environment must become part of the education system (McLoughlin 1996:16). The impact of Technology should result in Technology Education. This is manifested by the fact that in order to control the dynamics of Technology we need to study Technology as a subject. This subject is Technology Education.

Children, as earlier mentioned, should be oriented to Technology as early as possible in their life. It is through Technology Education that this orientation can take place as early as elementary school. It is therefore important for the author at this stage to differentiate between Technology and Technology Education.

The term technology has already been defined as the application of knowledge to work and as a process by which we attempt to extend the human
potential by means of which we improve and control our world (Seymour 1993:5). Technological knowledge refers to how to use technical resources to solve practical problems and accomplish work. Technical resources include pencils, screwdrivers, computers, software and products of applied science. It also includes processes such as "planning, designing, prototyping or design testing and mass production" (Cousins 1981:50).

According to Braukman and Pedras (1990:19) Technology Education strives towards giving individuals an "understanding of the role all technical resources play in solving problems and addressing needs, as well as of organisational strategies to utilise Technology, whether simple or complex". It develops logic in students so as to understand why certain technological developments manifest themselves. According to Johnson (1989:9) one of the most important purposes of Technology Education is to equip children and young adults with the ability to understand and to participate in and cope with the world in which they live.

The author can therefore summarise that Technology Education seeks to empower individuals by giving them a way to control or at least to work effectively with their environment. Technology Education therefore helps the students to better understand and adjust to changes in their lives caused by changes in Technology. Having defined Technology Education and having
explained its parameters, the author will now outline the scope of Technology Education.

3.2 SCOPE OF TECHNOLOGY EDUCATION

Technology Education as an essential part of general education, must be made meaningful and valuable to all students and should provide opportunities to challenge all populations in schools (Ku 1993:3). Technology Education places emphasis on the recognition of the differences in purposes, talents and potentialities of all students (Wright and Lauda 1993:3). Technology Education has a unique content base, "that is similar to Science and Mathematics" (McCade and Weymer 1996:49). The content base of Technology Education is therefore derived from these two disciplines.

Students can be kept abreast of technological developments by being taught how to learn how to do research and do experiments. Students are taught how to locate information and how to develop life-long learning capabilities through Technology Education (Wright and Lauda 1993:4). Technology Education fundamentally consist of the use of efficient practices in order to solve practical existential problems, and this entails the "design and use of tools and devices and the creation of artefacts" (Lewis and Gagel 1992:117).
According to Braukman and Pedras (1990:19) Technology Education is an educational programme that assists people to develop an understanding and competence in designing, producing and using technological products and systems and in assessing the appropriateness of technological activities. Technology Education requires a shift from the specific project oriented content of the past to a more universal and process oriented approach (Koppel and Miller 1987:77). It involves a continuous interaction between the knowledge base and the political, social and technical components of the environment.

"Issues of learning in context, the social nature of learning, the importance of hands on learning, and the need for reflection on the learner are prevalent in Technology Education" (Johnson 1996:47). Technology Education seeks to develop in all students an understanding and appreciation of technological processes and products and the impact these developments have on our lives. These are manifested in the aims of Technology Education to be discussed in the next paragraph.

3.3 AIMS OF TECHNOLOGY EDUCATION

Technology Education aims towards helping students to develop an understanding of Technology and its dynamics, the opportunities it offers, and its impact on product and process markets, organisation structures and
people (Fulcer 1996:15). Through Technology Education the student should
"apply knowledge of technological concepts, processes and systems"
(Hedcom 1996:12). The student should apply tools, materials, processes
and technical concepts safely and efficiently. Technology Education should
enable the student to apply skills, creative abilities, a positive self concept
and individual potential in Technology (Searles 1984:547).

Technology Education should assist individuals to reach decisions by
making value judgements resulting from "rational actions in the gathering,
analysis and interpretation of data pursuant to the problem prior to making a
decision" (Searles 1984:547). It should also enhance the ability of citizens to
function effectively and contribute to a technological society and global
economy (Monroe 1995:4). Technology Education should help students to
recognise and explain the importance of Technology. Students should be
helped to uncover and develop individual talents and apply problem solving
techniques.

Technology Education should help students to apply skills and knowledge
gained in the study of other school subjects. It should enable students to
apply creative abilities and deal with forces that influence the future. Lastly,
the student should be helped to adjust to the changing environment,
become a wiser consumer and should be assisted to make informed career
choices.
Technology Education is provided to students by developing in them (Wright and Lauda 1993:4) competencies to:

- Select appropriate technological procedures and services to meet personnel and group needs;
- effectively communicate technological information and ideas;
- describe Technology in a historical and evolving society context;
- use problem-solving, decision-making, invention and innovation to design technological devices and systems;
- effectively use tools, materials, and machines to provide technological devices;
- assess the personal, social, economic and environmental impacts of Technology; and
- use appropriate personal and interpersonal skills in participating in the technological society as a citizen, voter consumer and worker.

According to Johnson (1989:9) the United States school systems must modify their curriculum to adequately prepare students to live and function in the 21st century parallel to technological advances. Technology Education is positioning itself to remain an essential part of the school curriculum and the future looks bright for this exciting profession (Neden 1994:29). The Technology Education curriculum is designed to be action based and to provide students with the opportunity to apply creative
problem solving skills for the solution of technological problems (Koppel and Miller 1987:78). "It should provide transferable skills and understandings that can be applied by students to rapidly changing situations" (Ibid:79).

Through the Technology Education curriculum concepts of Science, Mathematics, Humanities and the Arts will come together (Seales 1984:545). This issue will be dealt with later. Scientific knowledge is applied in solving practical problems in Technology's attempt to manipulate and thereby manage the environment. The effects of Technology Education development therefore may be of a positive or negative nature (Searles 1984:545). The content of the curriculum should reflect the fact that contemporary Technology Education knowledge is tentative and subject to modification as further evidence becomes available or as new technologies develop.

Learning activities that enable students to understand how societal values can influence developments in Technology should be incorporated in Technology Education (Lewis 1981:37), as a means of attending to meeting a continuing technological need. The technology Education curriculum should develop an awareness of the long-term consequences of technological developments. The presentation of topics that illustrate both negative and positive consequences is vital. Examples of negative consequences could be the "smoke coming from exhaust systems of automobiles and industries resulting in air pollution while an example of
positive consequences could be the invention of a cellular telephone". The curriculum should enhance the social responsibility of the citizen.

According to Lewis (1981:37) the Technology Education curricula should cover the following topics:

- agriculture and food production including insecticides, fertilisers, herbicides and improved production;
- management of resources (renewable and non-renewable);
- medical, science and health care (nutrition, preventative medicine, and disease control and surgery);
- transportation (locomotives, automobile, aircraft and spacecraft);
- information technology (computers, and data captures);
- material (natural resources);
- industrial production (metal and wood); and
- construction (civil, road, housing and electricity).

The Technology Education curriculum must be suitable for the grade level it is intended for and the organisation of content may range between one whose subject matter is fully integrated to a curriculum that merely relates to 15-20 percent of societal issues to a relevant topic (Marland 1982:31). The Technology Education curriculum should involve materials that allow the students to investigate and understand those aspects of technological development that are vital to the health and welfare of society.
The conceptualisation, design and implementation of the United States Technology Education curriculum has ranged from the "co-operative efforts of large groups to the personalised approach of the individual teacher" (Hales and Snyder 1981:31). Finally according to the author, the curriculum should recognise that societal problems continue to warrant an understanding of Technology.

3.4 TECHNOLOGICAL LITERACY

Literacy is defined as the ability to record and write for the purpose of gaining and expressing knowledge. Therefore Technological Literacy is a "subject of Basic Literacy that focuses on Technology" (Wright 1993:6). "Technological Literacy is basic to education just like literacy in Language, Humanities, Arts, Mathematics and Science" (Johnson 1992:3). Technological Literacy is the "possession of understandings of Technological evolution and innovation, and the ability to apply tools, equipment, ideas, processes and materials to the satisfactory solution of human need (Pucel 1992:333).

"Technological Literacy is a concept used to characterise the extent to which an individual understands, and is capable of using Technology" (Ibid:3). Technological Literacy is a characteristic that can be manifested along a continuum ranging from non-discernible to exceptionally proficient. As such it involves an "array of competencies that includes basic functional
skills and critical thinking, constructive working habits, a set of generalised procedures for working with Technology, actual technological habits, key interpersonal and teamwork skills and the ability to learn independently" (Dyrenfurth 1991:179).

The aims of Technological Literacy are two-fold in nature. Firstly they should be understood in a social context and secondly in a technical context. The social context is based upon a socio-economic/political need to provide literacy for technological decision making in a democratic society. The technical context is based upon the need for competence in utilising technology in education/business/industry. The broad based science/technology/society programmes that are primarily delivered by non-technologists best illustrate the social context whilst the technical context is best illustrated by Engineering, Vocational and Technology Education programmes delivered by engineers and technologists (Wright 1993:3). More social context materials are included in education programmes to provide a more holistic view of Technology Education.

In order to be Technologically literate one must not only know Technology, but should also be in a position to practice Technology. A lot of writers though, emphasise the knowledge of Technology. Dyrenfurth (1991:141) identified the following about Technological Literacy; “that a person must have a broad understanding of Technology, understand the language, understand technological systems, be able to use Mathematics and Science
to solve problems and be able to use the design process to solve technical problems."

Basic Literacy may be divided into Scientific Literacy and Technological Literacy. In figure 3.1 below it is clear that both literacies are separate entities but overlap and both constitute Basic Literacy. One should be aware that Technological Literacy borrows from and lends to Scientific Literacy and both are part of Basic Literacy. The context in which one will understand and practice Technology can be explained within the confines of a strong knowledge base.

Figure 3.1: The context of Technological Literacy: Dyrenfurth (1991:141).
3.4.1 KNOWLEDGE BASE OF TECHNOLOGY EDUCATION

CURRICULUM

Dyrenfurth (1991: 141) concluded that Scientific Literacy and Technological Literacy fall under an umbrella called Basic Literacy (also see figure 3.1). It is also important to note that Basic Literacy has quite a number of components, which are neither Scientific nor Technological Literacy. We should also note that Basic Literacy is part of Cultural Literacy (Hirsh 1987:19). On the other hand, Cultural Literacy differs from one country or region to another. Cultural Literacy “deals about the everyday levels of knowledge that everyone possesses and below the expected level known only to specialists” (Pucel 1995:36). Cultural literacy serves as a knowledge base for Technology Literacy.

In identifying a lexicon that serves as a base for Technology Education knowledge, one will have to focus on the basic vocabulary of technology because the power of basic words can be used to develop thinking skills, organisation and ideas, arts and communication. Therefore basic words that impart important concepts should be selected as a knowledge base for Technological Literacy.

The knowledge of Technology entails understanding the lexicon and effectively communicating complex ideas. The doing of Technology is that aspect that reinforces understanding technological complexities. A careful balance between theory and application should be incorporated in
understanding of the uniqueness of assuming the responsibility for knowing and doing Technology in schools.

For a student to understand the lexicon of Technology we should try and identify the basic words that can lead to the understanding of technological concepts. These words can help us to bridge the gap between knowing and doing and creating powerful curricula that will allow students to understand the gestalt of Technology and all of its complexities (Wright 1980:36).

Students must not only be literate about the materials and processes of Technology, they must also be literate in the implication of these dimensions for the advancement of humankind and this is the reason why a basic lexicon must be identified so as to provide Technological Literacy. This lexicon should reflect Technology and its impacts on humans and the socio-technological environment, as to be literate means to understand how Technology impacts on lives at home, in the workplace, community and the world (Wright 1980:36).

The Technology lexicon should be made up of appropriate vocabulary, concepts and knowledge of technological systems. It should enable individuals to do problem solving effectively for the purpose of extending people's physical capability and security. The Technology lexicon should include concepts and theories that could be explained using a non-technical vocabulary, as these are more difficult to understand than those that require
At the general education and training level, use can be made of terms that give students a better understanding of Technology and how it affects their daily life. Such terms should be visible and usable on a daily basis for general education and training level students. At the further education and training level these concepts and terms can be made more abstract and they can be supported by an organized learning activity in which multiple concepts can be grasped rather with ease. *Appendix III* provides a vocabulary base for technological literacy at the further education and training level.

**Figure 3.2 : Lexicon Level for Technological Education: (Wright 1993:6)**
Figure 3.2 leads one to conclude that as the student moves through his studies from elementary to advanced study, the lexicon levels for Technology Education moves from broad to specific. It is an indication that Technological Literacy becomes more specific at higher levels of education. It also indicates that the lexicon level of difficulty increases as students move towards advanced studies. This trend with regard to Technological literacy could have a very strong influence when one curriculates Technology Education.

3.4.2 SIGNIFICANCE OF TECHNOLOGICAL LITERACY

Technological Literacy is an admirable goal for the Technology Education profession and internationally the study of Technology Education unites all countries in the sense that as the global economy continues to grow, technological abilities expand, and social responsibility for preparing the Technological Literate criteria of the 21st century becomes paramount (Wright 1993:7). Therefore all countries become involved in the world of technological competitiveness.

In the 20th century, as our society has become increasingly technological, many technology-based terms are being used in the mainstream of conversation. Popular mass-media, whether print or electronic, constantly use terms that originate from Technology. Thus, we need to have an
understanding of the concepts that underlie technology-based language if we are to be truly literate (Liao 1994:3).

In using technical terminology students "analyse designs, tool creation, tool use, prototyping and mass production under the general term Technological Literacy" (Braukman and Pedras 1990:20). We must all become more technologically literate so that we can make more decisions about personal choices as well as societal choices (Liao 1994:4). And if our democratic society is to thrive in an increasingly competitive global economy, we must use Technology more intelligently.

In order to be a successful professional and a contributing member of society, students of today will need to learn how to use new information and communication tools to solve problems, make more informed decisions and to be more productive. If these tools are successfully used, a more fulfilling life will be realised. Finally the structure of Technological Literacy is based upon knowledge and the ability to use and communicate technological systems, ideas and words (Education and Technology Task Force 1986:20).

Technological Literacy is manifested through Technology Education. Technology Education has a broad significance and application for education in general. It is usually taught within the confines of a specific
country’s environment and values. Therefore it tends to be taught within the confines of a specific culture. It is within a specific culture that Technological Literacy is actually embodied. This aspect will be discussed in detail later.

3.5 TECHNOLOGY EDUCATION AND CULTURE

According to Puk (1993:27), the implementation of Technology Education into schools involves "more than the rearrangement of the teaching/learning environment, more than the purchasing of new machinery and more than the packaging of intended learning into programmes and courses". As such it involves a set of behaviours which must spread far beyond the school environment. These beliefs and actions, which value the interdisciplinary nature of Technology, must ultimately be embraced by society in general if the goals of Technology Education are to be achieved (Puk 1991:16). These values and norms provide direction, meaning and energy for members of the organisation (Higgins 1994:462).

Furthermore, according to Puk (1993:32), Technology Education involves the "creation of a new culture, one which the larger society must eventually embrace if we are to be successful and one which creates new images".
3.5.1 THE CULTURE OF TECHNOLOGY EDUCATION

Puk (1991:13) lists the following characteristic for the culture of Technology Education;

- Technology Education should be for all students, at all grade levels;
- Technology Education is not an isolated discipline;
- all subject areas contain inherent technologies, the basics of Technology Education already exist in other subject areas;
- Technology Education involves human processes and environmental ecosystems, it is more than industrial machines, computers and other physical products;
- Technology Education is an interlink between what is intended to be created and the natural resources and other people;
- all citizens should acquire the knowledge and skills to be both intelligent consumers of Technology and doers of Technology;
- being doers of Technology means to be able to modify and make improvements in one's life, in the lives of those close to us and perhaps in the wider community, using simple technologies; and
- Technology Education deals with the relationships between techniques, people and the natural environment.

Technology Education is interdisciplinary by nature and belongs to all classrooms (Puk 1992:86). It links to an image of the educated person (Puk
1993:32), "who strives to improve the human conditions by creating new things or modifying existing things whether they be physical objects, environmental ecosystems or linear relationships".

3.5.2 ACCULTURATION OF TECHNOLOGY EDUCATION

Technology Education should empower the individual, each and every citizen of the state, with the knowledge, skills and confidence to be able to make simple changes in their lives, in the lives of those close to them and in the wider community. Citizens must be able to develop conceptual models to understand how Technology works. According to De Vore (1980:316) "the driving influence for the renewed appreciation for Technology are global preserves which have resulted from the rearrangement of the economic system".

Technology Education must not reduce human involvement in everyday life to an unhealthy economy. It should familiarise people and provide them with independence. Educational thinking in Technology Education should enable individuals to be knowledgeable about their technical means, and its relationship to individual freedom, society and the natural environment (De Vore 1980:316).

Technology Education is not an isolated discipline, it exists in all subject
matter and belongs to all teachers and all students. Schools from general education and training level to further education and training level should be transformed to equip all students with the higher order capacities of thinking and reasoning necessary to hold a good job at a high pay in the future workforce and participate in a complex society (Wirt 1991:428).

Acculturating a society to Technology Education requires a concentrated effort on the part of everyone. Teachers should make Technology inherent in all subject matter, especially general studies teachers who should also be assisted in making the explicit nature of Technology evident in their teaching. It should be borne in mind that Technology Education has a learning influence with regard to the economy, the improvement in the human conditions and the protection of the environment (Hammerman and Voelker 1987:29). When developing and implementing Technology Education more consideration should be given towards human behaviour when designing curricula.

The implementation of Technology Education into a school as a means of acculturation can be effected by using the following taxonomy of Technology Education curriculum concept as depicted in figure 3.3.
Figure 3.3: Taxonomy of Technology Education curriculum concepts

(Puk 1993: 29).

<table>
<thead>
<tr>
<th>Technology Education Emphasis</th>
<th>Central Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Processes</td>
<td>Structures</td>
</tr>
<tr>
<td>Physical Products</td>
<td>Structural Arrangement</td>
</tr>
<tr>
<td>Environmental Ecosystems</td>
<td>Materials</td>
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<tr>
<td></td>
<td>Fabrication</td>
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<tr>
<td></td>
<td>Mechanisms</td>
</tr>
<tr>
<td></td>
<td>Energy and power</td>
</tr>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Systems</td>
</tr>
<tr>
<td></td>
<td>The Aesthetic</td>
</tr>
</tbody>
</table>

The central concepts of structures, structural arrangement, materials, fabrication, mechanism, energy and power, control, systems and the aesthetic found in the curriculum emphasis of human processes, physical products and environmental ecosystems applies to any subject matter. These are generic in nature and they serve as suitable starting points for attempting to break down the barriers between disciplines and to attend to human behaviours that have traditionally kept those barriers in place. The taxonomy provides all teachers with a common starting point for further curriculum development and discussion as a result a positive culture could be created for Technology Education.
In order for Technology Education to be successfully implemented into the school it must be viewed by all in a generic sense. Technology Education must be perceived as belonging to the school rather than to specific groups of teachers or in areas of the school where students are labelled as outcasts or slow learners.

Any implementation plan for Technology Education must proceed cautiously and gradually. As acculturation proceeds, new images are being created and old ones altered or even abandoned. During implementation sensitivity must be created and maintained between old and new images.

To enhance the integration of a culture of Technology Education into the education system, all teachers must be perceived as being teachers of Technology Education. General studies teachers who "integrate Technology Education into their classroom at the primary, junior and intermediate levels will also be known as Technology Educators" (Puk 1993:30). According to Puk (1993:30) all teachers are potential teachers of Technology Education.

The implementation of Technology Education should not proceed using methods, which have not worked in the past. Sensitivity and inclusive behaviours are important considerations in the acculturation of Technology Education into schools and into the larger community. Added to the acculturation of Technology Education into the education system
are various myths that may inhibit the successful adoption of Technology Education by all students in respect of gender or cultural backgrounds.

3.6 MYTHS IN TECHNOLOGY EDUCATION

3.6.1 TECHNOLOGY EDUCATION PERCEPTUAL DIFFERENCE BETWEEN GIRLS AND BOYS

According to a survey undertaken by Penfold (1988:33), it was suggested that girls experienced discrimination in school, this coloured their perception of Technology subjects and the skills needed for success in those subjects. In a study by Rennie (1987:133) it was found that girls had a less positive view of Technology Education than boys at the same age of 13+, as a result girls were less likely to want to go on and study Technology Education or to work in Technology related occupations. It was suggested that this might have been based on experiences prior to secondary education. Nash, Allsop and Woolnough (1984:18) had earlier also found that girls were normally ignorant of Technology Education and were unlikely to choose Technology Education as a subject.

In the United States, in a bid to offer a new Technology Education curriculum, detached from the old craft curriculum, means have been made to develop technological skills as part of the school experience for all pupils
McCarthy and Moss (1994:6). McCarthy (1992:3), in his study measured male and female attitudes towards Technology subjects, as part of a broader study on pupil's attitude towards Technology Education. The older craft subjects represented one area of the curriculum where gender stereotyping had been prominent in the past as measured by pupils choice of options despite the efforts of curriculum designers and school arrangers to overcome such stereotyping.

The study by McCarthy and Moss (1990:202) was aimed at determining whether males and females have different perceptions and values towards Technology Education related programmes. The study sought to measure the perceptions of male and female pupils towards different subject groups by asking them to complete semantic differential ratings to describe pupils interest in four distinct curriculum areas i.e. Science, Humanities, Technology Education and Craft.

The result of the study according to McCarty and Moss (1990:216) indicated the following:

- Technology Education is opted for by both girls and boys in relation to its value in gaining employment or a place in higher education;
- constraints imposed by option choice in choosing Technology Education are not significant factors;
• the influence for the choice of Technology Education courses for both boys and girls is enjoyment of the subject and success in early secondary school;

• Technology Education is opted for by female pupils as a possible career and design realisation and design communication are opted for because of enjoyment of the subject;

• boys seem prepared to accept lower levels of success in Technology Education than are girls; and

• boys and girls seem to have the same perception of Technology Education in relation to Science and Humanities

These findings reflect two trends that will be discussed shortly. Firstly it seems there are no longer any significant differences in perception of Technology-related subjects between male and female pupils. Secondly Technology Education appeals to female pupils more than were the case for the older style craft-oriented courses. The reason cited for this perceptual trend is that Technology Education is seen to be more academically vigorous and offers opportunities for entry into higher education or meaningful employment for both sexes (McCarthy and Moss 1994:12).

3.6.2 GENDER-CARE

Technology Education with its roots in Industrial Education must include education that is appropriate for both girls and boys (McCarthy and Moss
Since the early 1990s there have been women who have left their mark in Technology Education history although there had not been nearly enough women to represent or be appreciated for their perspectives in Technology Education. Technology Education history should be interesting and important to all. There should be a continued drive to provide Technology Education to all, thus recognising the need to include all minorities. Women played an important role in Industrial Education in the 1800s and that role has only increased in value as customs of today and tomorrow continue to change (McCarthy and Moss 1994:13).

Differences between genders and individuals and values should be respected and valued especially their contribution to Technology Education (Trautman 1995:40). Women in the field of Technology Education have a responsibility to communicate their concerns to others, both men and women. This communication should be viewed as a constructive way to bring concerns to light. "The biggest barrier to women advancement is working with and for men who believe they are gender equitable, say they are unbiased by not recognising them and pointing them out" (Trautman 1995:40). Another barrier is the resistance of many men to be managed by or work closely with a female as they may feel uncomfortable, they may say something offensive or they may not be able to act or say things as they always have. This barrier is simply unacceptable.
It is therefore the responsibility of women to prove that they have the qualities and can handle the pressures that go along with upper level jobs. Technology Education must continue to demonstrate its need for women and communities to help provide Technology Education for all students, and teachers have a key role in assisting new teachers including women in being literate in Technology Education.

It is commonly believed that if South Africa wants to nurture female talent for leadership roles, “we must not only show support, but take action” (Trautman 1995:41). Considering the often elective nature, stereotyping and tracking of non-college bound students into Technology Education courses, Technology Education courses have the added responsibility of ensuring a qualitative and meaningful experience (Volk 1995:37).

In the U.S.A women’s contribution in Technology Education and Industrial Education came from two different areas. Firstly women labelled as educationist reformers in general opened the way for women in education. Women in the 1900’s advocated Industrial Education (Trautman 1995:31). According to Newcomer (1959:25) “women in the 1900s believed that women should have access to education that would prepare them for either a vocation or a role as homemaker through which they pass information to their children”.
Secondly, United States schools in the early 1900s taught Industrial Education. Schools provided direction, acceptance for learning and an open place for women to learn. They also provided education regarding consumer issues, hobbies and survival (Newcomer 1959:90).

Today the situation is different. Girls are more independent. Professionalism is now for both girls and boys. They stand the same chance in undertaking Technology Education, because society is transforming daily. Society accepts that boys and girls can venture into College and into some other professions equally.

3.6.3 DIVERSE TECHNOLOGY CULTURE

Technology Education as a profession has no more to offer minorities and women than Industrial arts did, but it does have the potential for an organisational culture which will be more receptive, attractive and conducive to success for these individuals (Liedtke 1993:14). According to Thomas (1990:110) the management environment must help people to understand that a culturally diverse organisation enables everyone to contribute to their greatest potential by integrating minorities and women to the work force. Such an environment should create a heterogeneous culture in which people differ in many ways, including age, education, background, function and personality (Higgins 1994:476).
In reviewing the present culture of an organisation, means should be made available to change it to be accommodating and discard stereotypes. It is also important to note that individuals vary widely in their openness to and enthusiasm for change and the person most comfortable with any particular change is the one proposing it (Carr 1994:55). In changing an organisation it is imperative that the factors that matter in change and their impact on the people to be changed should be looked at (Ibid:56).

Everyone in Technology Education should show serious commitment for reviewing the organisational culture of Technology Education, the profession's attention to cultural diversity and the process itself (Liedtke 1993:14). Remember that changes require an examination of values and beliefs, organisational systems and goals because they challenge the vestiges of the past. There must be a familiarity with diversity issues and the change process. It is therefore important that the organisational culture should change people to accept diversity. People's values, processes and standards of organisational behaviour should be transformed. Specific goals should be targeted, either changing the organisation or changing individuals or both (Rosselt and Bickham 1994:41). This can only be achieved through a supportive programme that will take into consideration gender and cultural diversity.

The organisational culture of Technology Education should be made attractive for women to encourage them to participate in Technology
Education as a profession. The organisational structure should provide values and norms which women can best identify with (Barney 1986:657). Technology Education must develop and reinforce its own organisational culture and must create change that ensures diversity. Technology Education must have an organisational culture that match the individual personalities of women, perhaps more so than modelling their gender, race or ethnicity.

Technology Education must offer a broader range of contexts, which can fit a diverse range of individuals by changing an organisational culture. Attraction should be aimed at individuals with personalities and interest that fit the organisational culture (Deal and Kennedy 1992:17). An assimilation process should be made available to ensure less resignation and as a means of providing respect for individuality and to welcome people who are different to the organisation (Dellate and Baytons 1993:56). These enables new people in the organisation to alter their attitude to suite the organisational culture.

Finally, Technology Education as a profession is challenged to create equity at all organisational levels. Technology Education should recognise the value of diversity and embark on a productive activity to enhance participation by women and minorities. This is a means of creating harmony and enabling people to appreciate each other. Therefore the Technology
Education programme should incorporate the recognition of diversity and enhance productivity.

### 3.7 LINKING WITH THE TECHNOLOGY EDUCATION 2005 PROJECT

The Technology 2005 project was initiated in 1994 as a project that would provide a National Curriculum Framework for Technology Education as a compulsory school subject in South African schools. This project was translated into a working document in May 1996. The challenge for the Technology 2005 project is therefore to develop a curriculum, which ensures opportunities for learners to develop shared understandings, specific personal qualities and perceptions and a range of useful individual skills.

According to the Technology 2005 project, “it is envisaged that by the year 2005 Technology Education will be part of the education of every boy, girl, teacher and learner in South Africa” (Hedcom 1996:2). Technology Education will be included in the South Africa curriculum with the aim of enabling South Africans to be creative, adaptable, critical, autonomous, entrepreneurial and employable citizens (Hedcom 1996:2) who can contribute meaningfully and responsibly to their own communities, South African society, the natural environment and the economy.
The heads of education departments committee seeks to ensure that by the year 2005 Technology Education is implemented as a compulsory school subject in all schools up to general education and training certificate level. Secondly Hedcom (1996:2) will ensure that Technology Education is offered as an option in the adult basic education and Training programme. Thirdly Technology Education will be offered as an elective subject from grade 10 to 12 (further education and training certificate level). Fourthly, pre- and in-service teacher education and training programmes will be offered to enhance the expertise in Technology Education. Lastly the development of Technology Education courses will be linked to adult basic education training courses and the further education and training programmes.

Technology Education will be allocated at least two hours of teaching time per week up to the sixth year of general education. This should be partly provided for allowing Technology Education to replace existing subjects such as Handwork, Needlework, Woodwork and Craft where they exist (Hedcom 1996:21).

Between the grades 7 to 9 (Senior phase level) Technology Education is envisaged to be allocated between two and three hours teaching time per week. Firstly this may be partly achieved by replacing existing subjects as mentioned in the last paragraph or secondly existing subjects may be used to accommodate Technology Education in grades 8 and 9. According to
Hedcom (1986:21) Technology Education may be taken as a specialisation subject at the years 10 to 12.

Hedcom (1996:3) also views Technology Education as a subject linked to Languages, Communications, Humanities, Science, Mathematics and Technical subjects. Technology Education brings down artificial barriers between subjects by drawing across the curriculum in support of learners' attempts to solve real problems.

"Technology Education draws on knowledge information and skills learned in a range of other learning areas such as Language, Mathematics and the Natural Sciences and therefore it leads itself to integrated approaches to teaching and learning" (Hedcom 1996:5). The author will elaborate further about the integrated approach.

The Hedcom project discusses Technology Education activities broadly but this is specified in-depth by the author in chapter 4. The author will also discuss in detail various delivery methods applicable to Technology Education. These methods will also be discussed in chapter 4.

As much as assessment standards have been labelled as very important by the Hedcom project the author will also give an in-depth elaboration of evaluation standards in chapter 4. The author will also elaborate on the
relationship between Technology Education, Science and Mathematics. This relationship will be highlighted in chapter 4. Finally, the establishment of the Hedcom Technology Education project is a massive step towards enhancing citizens with the capacity to engage in technological activities and develop optimum solutions to technological problems (Hedcom 1996:13).

3.8 SUMMARY

Technology Education is a dynamic purposeful intervention act that empowers students with skills, critical thinking, decision making powers and problem solving techniques that enables them to deal effectively with available challenges in their environment. Technology Education should be differentiated from Educational Technology and Technology but its scope should be seen within the context of the two.

Technology Education brings the concepts of Science, Mathematics, Humanities and Arts together. Chapter four will give a broad overview of this relationship. Technological Literacy is a cornerstone for the knowledge base of Technology Education.

Technology Education as mentioned in the text involves a new cultural dimension. It involves a set of behaviour patterns, which must extend far
beyond the school environment. Finally, in this text it has also been evidenced that Technology Education should not be seen as a subject for boys only, it is therefore important that girls should be enabled to prove that they have the qualities and potential to participate in Technology Education.

The Technology 2005 project is a major achievement in South Africa as it came as a relief to South Africa's present problem of inadequate development in Technology. Finally, as mentioned earlier, the cornerstone of the project is envisaging that by the year 2005 Technology Education will be part of the education of every boy, girl, teacher and learner in South Africa.
CHAPTER 4 - GUIDELINES FOR TECHNOLOGY EDUCATION

4.1 GUIDELINES FOR A TECHNOLOGY EDUCATION PROGRAMME

In presenting guidelines for a Technology Education programme the author will discuss the nature of the programme, the characteristics of Technology Education activities, guidelines for the teacher as a facilitator and various Technology Education teaching strategies. The strategies to be discussed will be problem solving, the design process, decision making, multimedia as an approach in teaching Technology Education, integrative teaching and group and self-activity projects.

4.1.1 THE NATURE OF A TECHNOLOGY EDUCATION PROGRAMME

Technology Education in the United States at undergraduate level deals with concepts and provides experiences dealing with modern communication, construction, manufacturing and transportation systems. At the postgraduate level it deals with the “research in more advanced problems and engage in curriculum development” (Wright 1993:19). The focus will be what should characterise Technology Education at further education and training levels in South Africa.
Technology Education should be action-based. It should provide first hand practical experience as a means of gaining understanding of concepts. Technology Education is the application of resources to solve problems and extend human potential. It provides the real world situation for the application of Mathematics and Science. “Discoveries of Science that benefit the human race are applied through Technology Education” (Seymour 1993:15).

Technology Education curricula, although varying from one institution to another, are characterised by the topics communication, construction, manufacturing and transportation with the utilisation of energy as a common theme across clusters of topics. Technology Education processes offers satisfactory solutions to problems and problem solving is a core methodology of Technology Education.

Technology Education should be career oriented in the sense that skills received in Technology Education predispose a student to different careers. A student can follow a career in either the private or public sector. There is a strong need for technologists as teachers as well as in the public and private sectors. The Technology Education programme should also be characterised by various Technology Education activities. Lastly, a Technology Education programme should be culturally friendly and it should appeal to both boys and girls.
4.1.2 THE CHARACTERISTICS OF TECHNOLOGY EDUCATION ACTIVITIES

Technology Education activities should encompass the problem centred approach governed by the student's needs and wants (Braukman and Pedras 1990:2). The planned activities for all students must be logical, scientific and systematic and contingent upon the individual ability. Through these Technology Education activities children can obtain a better understanding of Technology Education and its impacts, thus become technologically literate (Ortega and Ortega 1995:1).

Students should be enabled to develop intellectual capabilities by solving technological problems, developing thinking skills, curiosity and creativity. Through the development of problem solving skills their self-esteem and self-confidence develop. Choices of Technology Education activities should also be related to the needs of creative students to enable them to execute own projects.

The nature of Technology Education dictates that a variety of specific activities can be chosen for a particular learning programme. According to Braukman and Pedras (1990:2) these Technology Education learning activities should meet the following criteria:

- they should be safe;
- they should have high learning potential;
• they should concentrate on the process, not the product;
• they should be low cost activities;
• they should use Technology that is user friendly; and
• they should stress active learning.

(a) Safe activity

Dedicated Technology Education resource rooms should be used wherein a Technology Education specialist should teach continuously for several periods. If such a resource room is not available an activity area should be developed in a particular classroom and a tool chart should be made available. All these ventures should be made to make Technology Education as safe as possible, to avoid damage and injuries.

(b) High learning potential

Several learning strategies can be clustered together and several layers of learning can emanate from one single activity to enable students to create and control their environment. This can include, for example, tools such as an electric motor, microscope, engine, etc. Common tools for society are often organised into more manageable content areas such as communication, manufacturing, energy and power and transportation. "Learning about these is valuable for future citizens" (Braukmann and Pedras 1990:21).
The teaching of core subjects such as Mathematics and Science can at the same time be supported. Core subjects can be easily incorporated into an interdisciplinary activity by having students write reports, use Mathematics, research design options and create theme exhibits.

Students can also be introduced to useful processes that include defining problems, setting criteria, research, brainstorming, evaluation, developing a prototype model and evaluating the model. This creates a climate for modelling problem solving skills, creativity and critical thinking. Including skills related to communication, organisation, planning and co-operation can enhance co-operative learning.

(c) The activity concentrates on the process not the product

Technology Education activities should enhance skills such as the development of planning, research, creativity, problem solving, evaluation and critical thinking. The use of Mathematics and the application of scientific principals should form part of the activity.

Activities should call for skills that produce dividends for students in areas of self-esteem, work ethics, patience, attention to detail, improved motor co-ordination, and recreational fulfilment. Activities should emphasise function over form. They should emphasise effectiveness and efficiency and scientific principles as well as quality control. In short, activities should show
the whole process undertaken to produce a product and not only the product itself.

(d) Activity has low cost

Technology Education teachers should use low-cost materials. Materials can also be easily re-cut into the necessary sizes for Technology Education projects. According to Braukman (1993:25) “the core process critical to an understanding of Technology Education such as tool creation, and use, design, prototyping, mass production and the application of scientific principles can be well understood through the use of inexpensive materials”.

(e) The activity uses technology, which is user-friendly

Technology Education activities must be designed to produce students success through the use of simple tools and simple materials to illustrate concepts and processes in science, manufacturing, communication and computers. The activity should be judged a success if the project works without producing danger, therefore function should always be emphasised. This should be done without any imminent physical danger to students.

(f) The activity stresses active learning

Although students have various learning styles, very few utilise only visual and auditory styles (Dunn 1981:31). According to Dunn (1981:31), an active, tactile, manipulative learning style is the most common in young
children, as a result Technology Education should take advantage of this style.

Spatial visualisation skills and various experiences are strengthened by activities that allow the manipulation of tools and materials to construct objects. This is an aid to tactile learning (Grieve and Davis 1971:138)

Through the variation of the subject matter and the variation of the manner in which it is presented, student activity is improved (Johnson and Thomas 1992:8). According to Hull (1992:17) "effective teaching takes the student from concrete to abstract, from specific to general, from practical to theory and from familiar to unfamiliar" and at all times the focus is on the student activity. It is at this stage, therefore, imperative that the author discusses the role of the teacher in the Technology Education programme.

4.1.3 THE ROLE OF THE TEACHER IN THE TECHNOLOGY EDUCATION PROGRAMME – FACILITATOR

At the heart of a good Technology Education programme is a teacher who displays enthusiasm for the content, the students and the school (Seymour 1993:15). Technology Education teachers should direct programme in such a way those students learn about the technologies which will impact on their futures. Students should each be motivated to develop new insights, create
important understandings and enhance personal and group skills. The Technology Education teacher should serve as a local source of experience and wisdom regarding the benefits of technology and the best ways to introduce applied concepts into all parts of the school curriculum (Homan and Clark 1996:33).

Teachers should exhibit a genuine concern for young people, whether in a formal classroom, the laboratory or during extracurricular activities by displaying intelligence, concern, personal warmth, leadership and dedication. This concern should be addressed through the already mentioned Technology Education activities.

As technology is growing at a fast rate, the Technology Education teacher also faces the challenge of remaining up to date. Technology Education teachers are those best prepared to possibly direct the nation's future because they are the key to learning-schools. Teachers should help organise and conduct Technology Education programmes in the school so as to enable students to apply modern technologies in an appropriate manner (Lovedahl 1993:18). Technology Education is in a unique position to provide a leadership role in the development of programmes that will provide students with the competitive edge to deal with life, therefore it will need competent teachers.
In the United States of America, Technology Education educators have roots in the old Industrial arts programmes. It is likely that all too few at present have the background necessary to develop and present "a new programme of Technology Education that will do justice to the holistic view of Technology" (Johnson 1992:4). It is important to also note that some Technology Education teachers in the United States of America have made substantial efforts to include the social aspects of the fields they cover.

Technology Education teachers should use a co-ordinated approach to teaching by integrating various subjects in Technology Education. Educators must come to understand the difference between Technology Education and the use of technological means for education such as computers and videos. Educationists must understand the difference between Science and Technology Education, between Technology Education and Vocational Education (Savage and Sterry 1990:3). They must understand the need for a technologically literate citizenry and for a well prepared corps of future scientists, engineers and technicians.

Every Technology Education teacher "must become a disciple of the profession and make an extra effort to educate those who have not had the fortune of experiencing Technology Education" (Monroe 1995:3). The teachers of Technology Education need to establish Technology Education as a major core subject in the school. This is the case in South Africa, the
Technology 2005 project already proposed that Technology Education as a new subject should be made available to all citizenry by the year 2005 (Hedcom 1996:3). The strength of teachers will come from outstanding instruction that places hard work in the classroom and laboratories as well as from working in groups, so as to make progress and provide one of the most existing lay experiences in the field of education.

According to Foster (1994:31) "an educator must remain current in the research relative to the profession and must develop and maintain the ability to interpret, use and to some extent, conduct research". This serves as part of the professional responsibilities of an educator. Lastly the teacher must use relevant teaching methods in Technology Education. The author will now discuss the various Technology Education teaching strategies.

4.2 GUIDELINES FOR TECHNOLOGY EDUCATION TEACHING STRATEGIES

Teachers and students bring into the classroom different learning and teaching styles. Often the classroom situation represents the teachers personal style as "teachers tend to emphasise their own style in teaching" (Steinberg 1990:369).
Students who tend to progress more efficiently are those who have learning styles that match to the teachers learning style. It is also important to note that “basic learning matched with appropriate instructional strategies empowers the student’s ability to concentrate and learn” (Carbo, Dunn and Dunn 1986:76). A teacher’s attitude towards students and his instructional activities can contribute either negatively or positively to the teaching/learning experiences of students.

Effective teaching styles provide teaching in which developing people is the primary purpose of the curriculum rather than knowledge acquisition. Finally, it is important to note that learning and teaching styles should not be stereotyped.

Learning is a continuous transformation process which consist of four stages starting with concrete experiences, and then progressing through reflective observation, abstract conceptualisation and active experimentation (Henak 1992:22). This process thus develops four kinds of capabilities which require four kinds of environments i.e. affective, perceptual, symbolic and behavioural (ibid:22).

Teachers should use the four stages mentioned above as a guide when sequencing learning activities to ensure that students have meaningful learning experiences. Technology Education courses consistent with this
recommendation should increase Technology Education mastery in students, as they engage technological concepts not only through abstraction but also by direct experience. This strategy should be augmented by an approach where different media are integrated into the presentation of these learning experiences. The use of multimedia is a possibility in this regard which will be discussed later.

Technology Education teachers should be proactive and be leaders when in contact with their colleagues from other disciplines. Technology Education challenges the exclusive use of the lecture demonstration project model of teaching (Henak 1992:23) and encourages the use of the following five methods:

- problem solving;
- the design process;
- decision making;
- integrative teaching; and
- group and self-activity projects.

For the purpose of further elaboration the author will discuss the problem solving method, the design process, decision-making, the use of a multimedia approach as well as the integrative method and the group and self-activity projects.
4.2.1 PROBLEM SOLVING

Problem solving and decision-making are essential requirements for citizens to cope with learning situations in a high Technology Education environment (Ku 1993:31). Contemporary citizens must possess the competence to solve problems facing them and to use logical procedures in arriving at their decisions. Problem solving should address the technological “processes of creating, inventing and modifying” (Hill 1996:19).

Problem solving is a skill advocated in most Technology Education curricula (Winek and Borchers 1993:23), therefore problem solving is a “core method in Technology Education” (Seymour 1993:15). Various problem solving methods could be used to keep both the teacher and the student focused (Waetjen 1989:36). All the techniques have the same basic components (Lavoie 1991:81):

- a good problem solving statement;
- a research and development component;
- a testing of solutions component; and
- an evaluation component.

Problem solving provides a means of “understanding and receptivity to technological innovation” (Waetjen 1989:37). Technological knowledge enables students to solve technological problems in new and unique ways.
Problem solving represents a higher order of thinking skills (Lavoie 1991:81). Problem solving enables students to draw on their past knowledge and use assimilation and evaluation skills to solve a problem. Through problem solving a wealth of information already discovered can be applied. The Ideate model for problem solving is, according to the author, the most suitable model for technological problem solving and will be discussed in the next paragraph.

4.2.1.1 The Ideate model for problem solving

This model fits best with the scientific and presently used principles in many Technology Education classrooms. Todd (1991:3) provides a framework by which students can logically and in an organised manner solve technological problems. The Ideate model consists of a number of steps that serve to help the student focus on the problem and serve as the basis for a student support system. The six steps of the Ideate model are the following:

a) Identify and define the problem

This step is essential to ensure that students focus on the problem. Students' ideas must be adjusted to the time allotment, to the resources available and to their abilities.
b) Defining the desired goals and available resources

This step allows students to clearly define the goals and identify available resources. This step includes time for locating resources and exploring the laboratory. It provides clear direction as to the design requirement of the problem yet provides plenty of opportunities for creativity. "Problems are questions of matter involving doubt" (Ku 1993:31).

c) Exploring a possible solution

This step is the most detailed and richly oriented section in which students analyse the problem by reducing it into questions to be answered. It is richly oriented because it involves the crux of what Technology Education is all about. These questions should be explored by using resources such as the library, classroom and the community. After exploring resources, students should analyse the problem statement to find workable solutions to the particular problem.

d) Assessing the alternatives

Alternative solutions to a problem should be analysed by the students, with the aim of refining and selecting the best responses to the problem statement. Information gathered by students should provide them with the necessary knowledge to solve their problems.

e) Trying out the best solution

In this step students build a prototype of the best solution. The critique and
evaluation of their solution must be based on the specification of the original problem statement as deduced in step b.

f) Evaluating the matching of goals and results

This step describes how well the final product meets the original criteria. The solution should first be tested against conditions described in the problem statement in order to evaluate to what extent the results match the original goals.

4.2.1.2 The Technology Education teacher and problem solving

The teacher should be a facilitator in a problem solving process as he knows more about the problem to be solved than the students (Waetjen 1989:87). The teacher should not necessarily solve the problem but should ask students questions or suggest resources that will guide them in the right direction to solve the problem. Teachers should direct students towards sources of knowledge, teaching them the means of access and providing them with encouragement and support.

The teacher should establish problem solving teams (Reschke 1991:30) and thus "ask more questions, obtain more pertinent information and usually produce a higher quality solution" (Ibid:30). It is also important to note that large teams may produce fewer failures, but at the same time place less
demand on an individual's accountability. The teacher should also show confidence in the intelligence of his students (Ku 1993:32).

4.2.2 THE DESIGN PROCESS

The design process is another "important delivery method that is used in Technology Education regardless of grade" (Hill 1996:21). According to Hill (1996:21) there are various approaches to the design process. The author will use one of these approaches as advocated by Hill (1996:21). The design process also relates to problem solving and it involves five major stages that are "spiralled and connected" (Hill 1996:21).

(a) Developing a focus

In this stage, a problem, a challenge or an area of study is identified and an understanding of the problem, challenge or area of study is sought in order to describe the focus of the rest of the design process.

(b) Developing a framework

This is a brainstorming and an information gathering stage in which various solutions are developed and the required resources, facilities and knowledge for each solution are identified and refocusing with regard to the various solutions takes place.
(c) Choosing a best solution

During this stage each suggested solution is analysed so as to determine its appropriateness, feasibility, advantages and disadvantages. Through this analysis a preferred solution is eventually selected.

(d) Implementing a plan

A system or artefact is produced as a prototype after exploring various means of implementing the selected solution.

(e) Reflecting on the Process and the Product

The prototype is tested and evaluated by the student by examining its functions and reflecting on the making process.

A written documentation of the product and process is finalised in order to communicate the results.

4.2.3 DECISION-MAKING

Todd (1991:24) presented a taxonomy to describe capability with regard to technological decision-making. The taxonomy embraces the following five areas (levels):

- awareness;
- literacy;
- ability;
- creativity; and
- criticism.

These five levels are related and are concerned with the knowledge of the practising of Technology Education. These levels also progress from awareness to more difficult areas of criticism and judgement. According to Todd (1991:24) competency regarding these levels could be accomplished through the use of problem solving in Technology Education. It should therefore be realised that there are various competencies that should be attained when practising decision-making in Technology Education.

Awareness is concerned with doing and perusing technology. Literacy on the other hand is concerned with knowing about Technology. Ability again is concerned with both knowing about and doing technology. The knowledge base of Technology depends upon circumstances and depends upon a given purpose. For instance if the purpose is directed forwards doing technology, then a highly specialised technological knowledge base is necessary. In the case where the purpose is to know about Technology in order to facilitate the making of intelligent and appropriate decisions then a more cultured and generalised knowledge base would be valuable. In Technology Education it is necessary to provide the students with a knowledge base and learning experience, which are both technological and conceptual.
4.2.4 MULTIMEDIA

Multimedia is a relatively new technique that offers unique opportunities for instruction as compared to traditional print and audio-visual modes. Technology Education teachers who want to take the challenge to create their own multimedia instruction should be aware that multimedia cannot solve instructional problems by itself. For Technology Education teachers the opportunity to bring applications of multimedia into the classroom or laboratory is an exerting challenge (Stier 1994:17).

Desmarais (1994:61) states that "anyone with the right kind of computer hardware and software can play, record and manipulate various types of media", and, as a result, enhance education activities. As there is an abundance of multimedia hardware and software in the market, Technology Education teachers should remain focused on the process of learning and communication rather than on a specific product or system (Stier 1994:17). Although software and hardware can rapidly change, the powers of developing effective instruction to improve communication, understanding and learning remains constant (Desmarais 1994:61).

Multimedia instruction may be learning through the process of analysis, design, protection, testing and delivery/maintenance (Sharpe 1993:13). The analysis phase takes place at various levels where the goals and expectations of the multimedia are determined. These include examining
present teaching situations and identifying potential applications where multimedia could improve the teaching/learning process. Opportunities to improve instruction with multimedia may also be analysed in the laboratory where many activities take place.

The other level deals with didactics. The teaching style and the impact of change with the use of Technology will have to be considered when analysing possible applications of multimedia. The success or failure of a multimedia application can be greatly influenced by "how students learn, and how proficient they are with computers" (Liedtke 1993:11). The multimedia justification for costs is the final level that will be considered in the analysis phase.

In the design phase the selection of appropriate media for each application is made. Selection is based on the evaluation of choices whether to incorporate graphics, animation, audio, video or other forms of media into the instruction. In the production phase a flowchart is created as an essential step for a teacher that produces his/her own multimedia. It should be accompanied by the identification of both decision points and entry and exit points.

When evaluating multimedia the teacher should play the role of the student and view the multimedia with the aim of identifying areas that need improve-
ment, from the learner's point of view. Lastly, after the improvements have been made, it is important to ensure that the individualised instruction is made as accessible as possible to students. During this phase evaluation can also be done by having students express their liking and/or disliking with regard to the multimedia as well as their recommended improvements.

4.2.5 INTEGRATIVE TEACHING

Integrating Technology Education in the existing curriculum is not just inserting another area of study, it is placing education in the context of the real world, as the everyday life is an integration of skills, knowledge and attitudes in the setting of a natural and a technological environment (Lazarov and Golovincky 1988:114). Integrating Technology Education is likely to make the education system more realistic and valuable for the students. Such a Technology Education programme should be based on principles of interdisciplinary education, co-operative learning, a flexible curriculum, and an emphasis on students as problem solvers (Olds and Lightner 1995:23).

Technology Education can be integrated into the themes or topics already being covered in other subjects. Goodman, Smith, Meredith and Goodman (1987:374) further elaborate on this by saying, "it is through integrated curricula experiences that children begin to see learning as a related whole rather than a meaningless fragmentation of subjects or skills." For an
example robotics can be studied from the perspective of Technology Education, Mathematics and Science. From a Technology Education perspective, one can understand the necessity of traffic control and the use of three kinds of indicators. From a Mathematical position one can understand the calculation of time for these robots to alternate and give direction whilst from a Science perspective one can understand why certain colours are used and why a certain voltage is used to give electricity to different lights.

Integrated Technology Education could enable students to solve most of their important societal, economic and environmental challenges (Seymour 1993:15). A course or two given in middle school does not adequately serve the integration of Technology Education into the general curricula. "Technology Education must become a part of all subjects as a consequence of the formal education of all teachers" (Johnson 1992:4).

Integrative Technology Education encourages and enables students to be curious and creative and develops their problem solving skills, as a result student's self-esteem is built up and their self-confidence is developed. It is an indicator to students that they can be both inventors and learners.

The use of materials and tools enable students to arrive at a solution and provides expressions in a unique and practical manner (Mills 1988:34). Therefore the divergent and convergent thinking skills of students are
developed. In their yearning towards developing their process skills, students also learn to co-operate and to work effectively in groups and develop as self-reliant individuals.

Technology Education could enable children to progress at their own level, as it can be adapted to the varied stages of development, capabilities and conditions. Advanced problem solving skills can also be brought about by integrated Technology Education activities. It makes education a meaningful and interesting experience for the students (William 1985:3).

Integrated Technology Education teaching builds sensitivity within students to understand how Technology alters the environments in which they live (Hutchinson and Hutchinson 1991:5). It enables students to exercise their social responsibility by considering the interaction between people and the natural environment.

Integrated Technology Education enables students to cope with the technological changes and choices they will be faced with as adults and improves education across all disciplines (Scarborough 1993:35). An integrated Technology Education programme utilises both a transetualist and transformationalist educational orientation. The transetualist orientation is the one that believes in the development of skills such as creativity, critical thinking and problem solving (Ortega 1995:12), thus enabling stu-
students to be actively involved in the process of developing their intellectual capabilities by solving technological design problems.

The transformationalist orientation focuses mainly on emotional and social growth and the natural integration of subjects. Awareness and ability within the individual to recognise and deal with the impacts of Technology is developed.

4.2.6 GROUP AND SELF ACTIVITY PROJECTS

Technology Education activities need to be planned thoroughly and students have to be instructed in the safe use of materials and tools. The following steps can be followed to integrate activities in Technology Education themes (Ortega and Ortega 1995:1):

- understanding what is meant by Technology Education and being able to identify whether artefacts or systems are involved;
- selection of Technology Education themes which are in line with the topic under consideration;
- planning Technology Education activities that are integrated into the theme under consideration; and
- assessing and evaluating the student progress.
There are two broad categories of Technology Education activities. These are Technology Education learning experiences and Technology Education design problems. These broad categories include other sub-categories, but for the sake of this discussion the author will only outline the two broad categories.

a) Technology Education learning experiences

These are the activities that provide the students with knowledge and understanding of technology and assist in developing their technological awareness as well as to acquaint students with the different types of technologies found in their environment.

These experiences could take the form of reading a story that deals with the Technology relevant to the topic. Field trips giving students direct exposure to the Technology artefacts could also be included. Exposure to Technology Education concepts through the use of film strips, films and videos could also be seen as Technology Education learning experiences. One example is visiting an electrical station where one can simply see that for a household only a maximum of 240 volts can be used. Refer to examples given in appendix iv of a standard 8 curriculum.

b) Technology Education design problems

Design problems enable students to explore various materials through
hands on experience and process skills. Students first need to understand the problem, and then they can brainstorm it for possible solutions and finally provide an appropriate solution. The final design solution should be evaluated by matching it with the original problem. As this process is not linear in nature, one or more steps may be repeated before a solution is achieved. An example of a design problem is building an artificial hand for a person who lost part or all of his hand.

4.3 GUIDELINES FOR TECHNOLOGY EDUCATION ASSESSMENT

Technology Education assessment standards should be assessment standards that will be appropriate for an education system in any developed country and these standards should provide "guidelines and leadership" (Monroe 1995:3).

The use of assessment standards to improve the quality of Technology Education will have an impact on the students, school, community and nation. Assessment standards enhance the overall quality of the Technology Education curriculum content, the instructional programme, the teaching methods, the physical environment, the laboratories, the preparation and the quality of teachers and the safety programme.
The Technology Education curriculum programme should be assessed through nationally developed and validated standards. The National Qualification Framework and unit standards that would be agreed upon in South Africa are likely to be used as standards in South Africa. Technology Education assessment standards should mandate that effective, open communication be established with all elements in the school system, especially those in Technology Education, Science and Mathematics and then used consistently by Technology Education faculty and staff (Monroe 1985:3).

Assessment standards should help inform non-Technology Education teachers, students and parents about the Technology Education programme, thereby generating opportunities for support, guidance and interdisciplinary educational activities. The items contained in the assessment standards can be used as promotional material to enhance the visibility of the Technology Education programme within the community (Dugger and William 1995:3). It is also important for the teacher to use the assessment standards to evaluate whether the intended instruction goals and objectives have been reached. The Technology Education teacher should do class work evaluation on a continuous basis and regular feedback should be provided to learners. Evaluation should be undertaken against the extent to which students develop problem-solving skills and make sound decisions.
When assessing a Technology Education curriculum, one has to evaluate this curriculum not only against the goals and objectives but also with regard to the interaction with Science and Mathematics. From time to time teaching and learning strategies should be evaluated. It would be preferable if a group of teachers evaluate a specific lesson after delivery so as to give the presenting teacher feedback about the effectiveness of the teaching/learning strategy for a specific portion of the learning content.

Group work, activity programmes and self-activity programmes should feature strongly as appropriate learning strategies for Technology Education. Evaluation of group work is likely to indicate positivity amongst group members and encourage students to know each other and engage freely in group work without despising each other.

Theoretical assignments should also be provided to students and the quality of their assignments should also be evaluated so as to provide the Technology Education teacher with a broad overview of students' limitations. By evaluating assignments, the teacher can deduce the extent to which Technology Education concepts are understood, and then attend the problem areas identified by the evaluation.

Learners can also be requested to write reports after field trips to companies, power stations, telephone stations, computer companies,
transport and production industries etc. From these reports a teacher can
evaluate the students' comprehension with regard to the particular
technologies. Obviously remedial work and regular feedback should follow
this up to learners.

Finally learners can write comprehensive monthly tests using worksheets.
These monthly tests can also be used to evaluate the student performance
over a period of time with regard to the particular curriculum objectives for
that period of time. As mentioned before, regular feedback should be given
to students and the relevant remedial actions should be taken to ensure that
the students have attained the desired outcomes.

4.4 GUIDELINES FOR INTEGRATING TECHNOLOGY EDUCATION, SCIENCE AND MATHEMATICS

4.4.1 INTRODUCTION

Researchers should still continue with developing competence or expertise
in disciplines such as Mathematics, Science and the Humanities, but
"developing relationships between these subjects and Technology
Education is equally vital" (Johnson 1992:4). Technology Education
integrates "the communication skills of language arts, the creativity of art
and the past experiences of the social sciences" (Froese 1988:88). The
nature of Technology Education is such that it incorporates vast areas of the
curriculum. It may also integrate the analytic approach of Science with the qualitative logic of Mathematics (Ortega 1995:15). The author will explore the relationship between Technology Education, Mathematics and Science.

4.4.2 TECHNOLOGY EDUCATION, SCIENCE, AND MATHEMATICS IN PERSPECTIVE

The activity or inactivity of a phenomenon occurring in a natural environment may be described, explained and predicted by a scientific theory. Through scientific theory man interprets the natural world. This interpretation is tentative as it is subject to further investigation in order to be refined or substantiated. However, scientific information emanating from this process serves as a useful base for practical technological developments (Siebold 1991:29). Technology Education teaching should use this scientific information to enhance the learning experiences of students and to develop their abilities with regard to technological innovation in general.

Science and Technology have come to share common ground. "Technology Educators have recognised the need for a solid grounding in the content of the physical and biological sciences and Science educators, through their emphasis on hands on and inquiry based Science, are recognising the value and importance of technological contexts and applications" (Custer 1996:8).
Science provides skilled manpower techniques and ideas for Technology. On the other hand, Technology provides innovative techniques and ideas such as the electron microscope and the radio telescope, which are essential for the development of Science (Hall 1983:23). There exists a complex interrelationship between Science and Technology especially when technological development is based on scientific theory. In this regard Technology Education ties Mathematics and Science together. It “makes learning more meaningful” (Thode 1996:8).

A technologically literate person understands the dilemma in decision-making activities during the development and application of technology while a scientific literate person has a substantial amount of scientific knowledge that enables him to learn, think and act in a logical manner, concurrent with scientific endeavours. Both these individuals are able to perceive the usefulness and limitations of Science and Technology Education to a society.

Science, Technology Education and Mathematics curricula should therefore include topics that illustrate the usefulness of contemporary scientific knowledge for understanding the implications of technological problems. These curricula should include those psychological problems relevant to the environment that can be understood through scientific knowledge.
Improving Science, Mathematics and Technology Education is a naturally acknowledged need in education directly impacting the economic success of the country“ (Scarborough 1993:35). Technological knowledge has existed far longer than scientific knowledge but the majority of technological inventions and innovations did not rely upon scientific theory for their development (La-Porte and Sanders 1993:17). It would appear that in the future the Technology Education curriculum will need to incorporate Scientific and Mathematical principles, seeing that Science and Mathematics continue to undergird technological development. There is a growing awareness of the important role Technology Education plays as it relates to both Science and Mathematics.

4.4.3 THEORY VERSUS PRACTICE

According to the author, Science and Mathematics has been strong in theory, but there is a general tendency to minimise the practical application of these two subjects. Recently there has been an increased emphasis on hands on activities that lead learners to be curious about the natural world. Science, Mathematics and Technology need to interact more because the application of scientifically, and mathematical knowledge to solutions of practical problems has often been limited to imaginary textbook examples.

Technology Education on the other hand has been strong in practice but weak in theory. Through problem solving activities Technology Education
provides practical, meaningful and motivating learning content for Science and Mathematics teachers. The concept of integrating Science, Mathematics and Social Research and experimentation activities is important (De Vore 1970:21), thus enabling students to develop social skills and to apply Mathematics, Physics, Chemistry and Communication skills in a practical and productive way.

The link between Technology Education, Mathematics and Science provides a number of advantages to the Technology Education profession (La-Porte and Sanders 1993:18) such as the universal presentation and cutting across of common themes. One of the obvious outcomes of bringing Technology Education, Science and Mathematics together is the development and implementation of curriculum materials that foster the integration of these three.

"Exposing Science and Mathematics students to the existing activities used in Technology Education has a positive effect on Technology Education enrolments in the future" (Dugger 1993:16). Figure 4.1 shows the overlapping nature of the relationship between Technology Education, Science and Mathematics.

Defining the three disciplines within each other's context will help the reader to understand the nature in which they overlap. Technology Education is
defined as the "study of our human created and controlled world and universe" (Dugger 1993:16) and Science is a study of "our natural world and universe" (National Research Council 1992:4), while Mathematics can be defined as a "study of all conceivable abstract patterns and relationships" (American Association for the advancement of Science 1993:14).

Figure 4.1: Overlapping nature of Mathematics, Science and Technology Education

Co-ordinating Technology Education activities with Mathematics and Science teaching can be used to reinforce the learning that takes place in Mathematics and Science classrooms. Technology Education problem
solving enables Mathematics and Science curricula to have its subject matter to be within the context of the real world, thus enabling Science and Mathematics principles learned to be applied to the real world setting.

Technological problem solving is predicated on the application of ideas and understanding to create practical solutions. It is also important to note that we have to instil a culture of Technology Education problem solving activities by employing Mathematics and Science in solving practical problems. Skills gained in Mathematics and Science should be viewed by students as problem solving tools, which are the same as problem solving tools in Technology Education.

Science is dependent upon Technology Education to test, experiment, verify, and apply many of its laws, theories and principles while "Technology Education is dependent upon Science for its research, laws, principles and knowledge base" (Dugger 1993:7). Technology Education is a "discipline on the same level with Science, should be compared with Science and it is perhaps itself a Science" (Dugger 1993:7).

4.4.4 INTEGRATION OF TECHNOLOGY EDUCATION, SCIENCE AND MATHEMATICS CURRICULA

Science is a field of study with several disciplines such as Biology, Chemistry, Physics etc. and Technology Education is also a field of study in
itself and its “disciplines are that of the practitioner” (Bensen and Bensen 1995:3). It is therefore a tool to describe the environment and it provides the base for design and problem solving.

Mathematics provides us with the analytical tools needed to create, alter, build and change our world and universe, therefore both the essence of Mathematics and Technology Education is problem solving (Dugger 1993:7). For an indication of the overlapping of Technology Education, Science and Mathematics refer to Figure 4.1.

Technology Education teachers are faced with the task of integrating Mathematics and Science principles into existing Technology Education curricula as Science and Mathematics are at the centre of the changes in human existence. Science and Mathematics are essential to the education of today’s children for tomorrow’s world. Finally, three important premises are linked to the integration of Mathematics, Science and Technology Education, which are of relevance to Technology Education teachers (Dugger 1993:7). These are:

a) There is a strong link between the study of technology and the appropriate application of mathematical and scientific concepts;
b) Technology Education with an activity based methodology can provide an excellent means of integrating Mathematics, Science and Technology Education into a relevant meaningful and fruitful learning experience; and

c) The current emphasis on Mathematics and Science provides a unique opportunity for Technology Education to establish itself as a viable discipline to be studied by all students.

4.5 SUMMARY

Technology Education, as a dynamic subject can only be enhanced and improved if teachers give attention to qualitative teaching, preferred learning styles and teaching strategies. In this context Technology Education teaching should be attractive to diversified people and should be manifested in a diversified environment. In this Chapter broad guidelines are provided regarding a Technology Education programme. These guidelines include the nature of a Technology Education programme, Technology Education activities, as well as the role of the teacher in a Technology Education programme.

Technology Education curricula should advocate problem solving as a central method that helps students to understand the essentials of
Technology. Technology Education teachers can also employ various other methods. The author also provided guidelines for various delivery methods that can be used in the teaching of Technology Education. These include the design process, decision making, integrative teaching and the use of multimedia and the group and self-activity projects.

It is important to note that assessment forms part of the Technology Education curriculum and it is deemed as a vital indicator of the success or failure of Technology Education. The author also discussed guidelines for assessing a Technology Education programme.

According to the guidelines for integrating Technology Education, Science and Mathematics, Technology Education is complementary to Science, and Mathematics. Although it overlaps with these subjects it is an entity on its own and it should receive the same status as Mathematics and Science in the school classroom.

The complementary nature of Technology Education to Science and Mathematics may also enhance the understanding of abstract concepts in Science and Mathematics. This may imply that academic performance in these two subjects may improve because abstract matter would be understood with ease. In the next chapter the author will explore the pilot study and the results of this pilot study will be used to explain the relationship between Technology Education, Science and Mathematics.
CHAPTER 5 - PILOT STUDY

5.1 THE COURSE OF THE EMPIRICAL RESEARCH: ITS DESIGN AND PROCEDURES

5.1.1 INTRODUCTION

The literature surveyed supports the fact that Technology Education has a considerable effect on the achievement in Mathematics and Science because the teaching delivery strategies used in Technology Education are linked to the underlying principles in Mathematics and Science (Custer 1996:8). Furthermore, according to Thode (1996:8) "Technology Education ties Mathematics and Science together". According to La-Porte and Sanders (1993:17), Technology Education incorporates Mathematical and Scientific principles and therefore enhances performance in both Mathematics and Science. Technology Education provides practical meaningful and motivating learning content for Science and Mathematics. This is evidenced in both developing and developed countries.

Emanating from the findings in literature the author decided to look at this implication by empirically checking the relationship in a South African context. The empirical research, which is a pilot study, was therefore undertaken namely to support or refute the implication of literature already
surveyed in chapter 2, 3 and 4. Although other factors related to Technology Education are explored in chapter 2, 3 and 4 it is deemed as important by the author that the pilot study be explored so as to qualify the assumption that Technology Education enhances performance in Mathematics and Science.

5.1.2 RESEARCH DESIGN

The variables explored in this study and their nature are such that they warrant an experimental study. Bailey (1982:166) defines an experimental study as "a study in which the author exercises considerable control over the experimental environment and the content, the author is enabled to attempt to establish causation rather than mere correlation and through this experience the establishment of causation is usually the goal of the study". The control and the experimental group consisted of students who passed standard seven in November 1993. The basic design of the present study is experimental. However, in the present study there is a comparison between two groups to validate that Technology Education enhances overall performance as well as performance in both Mathematics and Science.

The coinciding variable studied was overall achievement, achievement in Mathematics and achievement in Science as determined by the end of year (1994) examination in these subjects. English was also added solely
because it was a common subject among the experimental and the control group. The control group, did not receive Technology Education tuition, but received tuition in the science subject package at their respective schools. The experimental group, received Technology Education tuition for the whole year in one institution. Tuition in the science subject package was also included for the experimental group.

The Technology Education curriculum objectives were finalised through the Delphi technique in which participation of outside experts under the direction of the author was involved. According to Isaac and Michael (1981:79) by using the Delphi technique insight and experience of others can assist the Technology Education teacher build upon their own goals, experiences and interests for a more successful Technology Education programme. Two levels of the Delphi technique were used.

The author sent an original list of 49 topics covering Technology Education curriculum objectives to 14 professionals ranging from university tutors, high school teachers, industrial superintendents and two overseas experts in Technology Education. The ideas of these professionals helped the author to formulate 19 Technology Education curriculum objectives for standard 8, so as to formulate students activities through which these objectives could be attained (see Appendix II). The Delphi technique has been found to be an "applicable tool for educational research and curriculum development"
(Volk 1995:37). Its own future oriented application demonstrates its potential for developing the Technology Education curriculum. A 7 point Likert like, scale was used to prioritise the 19 objectives. This information is tabulated in Appendix II.

5.1.3 COURSE PROCEDURE

The experimental group received tuition in the normal Science subject package as well as in Technology Education. The control group also received tuition in the normal Science subject package but did not receive tuition in Technology Education. The Science subject package included Science, Mathematics, Biology, Geography and two languages, i.e. English and Afrikaans or a Black language.

Technology Education activities mentioned in Chapter 4 were used interchangeably over the year depending on the topic at hand. In the experimental study Technology Education teaching strategies as discussed in Chapter 4 were used in teaching various aspects of Technology Education.

What was important in the course procedure is the fact that an attempt was always made to integrate Technology Education, Science and Mathematics by relating common topics among these subjects. The performance of the
students was continually assessed. Work sheets, tests and group assignments were continuously provided to students, as a means of assessing students' performance.

5.1.4 TARGET GROUPS

In order to keep the investigation within a manageable scope it was decided to limit the target group to 116 subjects in the experimental group and 116 subjects in the control group respectively. An advertisement was placed in the newspapers asking for applications from prospective standard 8 pupils to attend a Technology College. Parents were also approached at meetings and seminars. Applications were received from students in Pretoria, the West Rand, the Vaal Triangle and the East Rand.

Altogether there were 232 applicants. The only requirement for admission was a pass in standard seven. The applicants were randomly distributed into two groups i.e. the experimental group and the control group. Each group consisted of 116 students. The students in the experimental group were informed that they had been accepted into the school. The control group was informed accordingly that they were not accepted but should keep contact for possible placement the following year for standard 9. Saturday school classes were organised for them in order to keep track of them over the year, as well as to ensure that their progress was monitored
and they received the same tuition as the experimental group in areas of Science, Mathematics and English.

Of the 116 of the experimental group 12 withdrew and could not be traced. Of the 116 of the control group 39 withdrew and could not be traced. Therefore 104 students were registered at the school as an experimental group and 77 were recorded as a control group.

5.1.5 DECEPTION

Deception involves informing the subject that he or she is part of a study but deceiving him or her about its true nature (Bailey 1982:43). According to the author the results of the study would have been biased if the subjects knew beforehand of the reasons why the study was undertaken, therefore the subjects were not told the exact aims of the study. The experimental group was told that they were the first group of students to receive tuition in Technology Education but the true nature of the project was not explained to them. The school was viewed as one of the good, newly established schools.

The control group was told that it was on standby for admission the following year. Both the target groups were, however, debriefed immediately after the end of year examination. The experimental group was told that the
whole year was experimental and they have an option of either leaving the
college for a mainstream, normal school, or they could continue in the
college until matriculation. The control group students were also told that
the year was experimental and the control group was given an option to join
the college or continue in their schools unhindered. Some of the control
group students were, however, recommended for admission the following
year after the end of the year examination.

5.1.6 HALO EFFECTS

The nature of the pilot study was such that the control of halo effects was
difficult. These halo effects included the quality of the teachers, the
availability of equipped laboratories and the disturbances brought about by
students' revolts, stay-aways or strikes. The author had full control over the
appointment of suitable teachers in the Technology College. This was not
the case with the control group. The subjects were spread over a number of
schools with different teachers. However, liaison was maintained with these
teachers. These students received tuition in all their school subjects on
Saturday nights throughout the year, Science, English and Mathematics
included.

Laboratories in different schools where the subjects of the control group
attended were ill equipped, unlike the laboratories at the College, which
were fully equipped. Because the control group attended extra classes on Saturdays, more attention was given to those areas that needed laboratory work.

As the Technology College was situated in North Johannesburg, away from the township, there was minimal disturbance brought about by riots and stay-aways. The same could not be said in the case of schools in the townships where mainly all the control group subjects attended. However, the author tried his best to make it a point that the control group also receive the same quality of education and that their year became minimally disturbed.

5.1.7 BIOGRAPHICAL INFORMATION

The author as part of the application form to the students compiled a biographical questionnaire. (See appendix I). The following biographical information was established; race of the students, whether they were repeating standard seven or not, gender of the students, parent income, nature of the household, sibling number, order of siblings in the family, town of origin and age. Their average examination mark in English, Science and Mathematics was also established including the overall examination percentage. The biographical information is presented in table 5.1 to 5.9 so
as to show the spread of the above mentioned variables among the two groups.

5.1.8 ANALYSIS PROCEDURES

Data was stored in a data bank through coding and it was fed into the computer, thereafter it was verified for correction of statistical computations. Means and standard deviations were calculated on the examination results for the control and the experimental groups. The significance of this data was evaluated by using statistical programmes contained in the Statistical Package for the Social Sciences (SPSS) (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975).

Hypothesis One as tabled on page 204 was analysed by the Univariate Analysis of Variance (ANOVA) on the four examination scores for November 1994 i.e. Average Examination marks, English marks, Science marks and Mathematics marks to determine if there was a significant difference between the scores of students who received tuition in Technology Education and those who did not receive tuition in Technology Education. English as mentioned was included because it was a common subject in both groups.
The Univariate Analysis of Variance (ANOVA) was also used to test Hypothesis Two as presented on page 210. The analysis was also done on the four subscale scores so as to compare the November 1993 and the November 1994 examination scores of the experimental group after the students had received tuition in Technology Education.

Hypothesis Three as presented in page 213 was also analysed by the Univariate Analysis of Variance (ANOVA) on the four subscale scores in respect of the control group comparing the November 1993 scores with the November 1994 scores (see page 188). The level of significance for the calculation of and the rejection of all the three hypotheses is set at 0.05.

Hypothesis One involved a total of 175 subjects in two groups. Hypothesis Two involved a total of 98 subjects in the experimental group and Hypothesis Three involved a total of 77 subjects in the control group. The analysis of the results is reflected further in this chapter.

5.2 ANALYSIS OF THE EMPIRICAL DATA: RESULTS AND DISCUSSION

5.2.1 INTRODUCTION

The author will now provide a report of the results of the statistical findings of the study. This is presented by first examining the descriptive statistics
and subsequently the inferential statistics of the Univariate Analysis of Variance (ANOVA) for the four subscale academic achievement dimensions. These results are organised by presenting the hypothesis tested, followed by a discussion of the results.

5.2.2 DESCRIPTIVE STATISTICS, A BIOGRAPHICAL COMPARISON OF THE TWO GROUPS

The author will reiterate the necessity for the inclusion of the biographical information as mentioned earlier in 5.1.6. The biographical information was gathered at the beginning of the year before certain students withdrew. Therefore, this information represents a total of 181 students. The biographical information was gathered firstly to show the heterogeneous nature of the students in the two groups and secondly to show the spread of the biographical variables among the experimental and the control group. For more information these biographical variables are presented in Tables 5.1 to 5.9.

The information presented in Table 5.1 indicates that 104 students were accepted into the school and therefore 104 students had to receive Technology Education tuition together with the other normal school subjects including English, Science and Mathematics. Of the 104 table 5.1 also indicates that 97,1% were Black, 2% Coloured and 0,9% White and no
other race was availed. Of the 77 in the control group 94.8% were Black, 5.2% Coloured and no Whites or other races. Altogether there were 181 students.

Table 5.1: Racial Composition of the two groups

<table>
<thead>
<tr>
<th>Race</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>101 (97.1%)</td>
<td>73 (94.8%)</td>
<td>174</td>
</tr>
<tr>
<td>Coloured</td>
<td>2 (2%)</td>
<td>4 (5.2%)</td>
<td>6</td>
</tr>
<tr>
<td>White</td>
<td>1 (0.9%)</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Other Race</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>104 (100%)</td>
<td>77 (100%)</td>
<td>181</td>
</tr>
</tbody>
</table>

In Table 5.2 the following is depicted as regards the demographic data of the gender of the control group and the experimental group: 48.1% percent of the experimental group were boys and 51.9% were girls; while 46.8% of the control group were boys, and 53.2% were girls. This distribution of gender was purely due to sampling.
Table 5.2: Gender Composition of the two groups

<table>
<thead>
<tr>
<th>Gender</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>50 (48.1%)</td>
<td>36 (46.8%)</td>
<td>86</td>
</tr>
<tr>
<td>Female</td>
<td>54 (51.9%)</td>
<td>41 (53.2%)</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>104 (100%)</td>
<td>77 (100%)</td>
<td>181</td>
</tr>
</tbody>
</table>

Table 5.3 represents the demographic data of the age of the students. The age of the experimental group ranged from 14 to 22 with the mode being 16 and the age of the control group also ranged from 14 to 22 with the mode being 16.

Table 5.3: Age Composition of the two groups

<table>
<thead>
<tr>
<th>Age</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>4 (3.8%)</td>
<td>5 (6.5%)</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>28 (26.9%)</td>
<td>24 (31.2%)</td>
<td>52</td>
</tr>
<tr>
<td>16</td>
<td>35 (33.7%)</td>
<td>27 (35%)</td>
<td>62</td>
</tr>
<tr>
<td>17</td>
<td>16 (15.4%)</td>
<td>9 (11.7%)</td>
<td>25</td>
</tr>
<tr>
<td>18</td>
<td>9 (8.7%)</td>
<td>8 (10.4%)</td>
<td>17</td>
</tr>
<tr>
<td>19</td>
<td>6 (5.8%)</td>
<td>1 (1.3%)</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>1 (0.95%)</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>4 (3.8%)</td>
<td>2 (2.6%)</td>
<td>6</td>
</tr>
<tr>
<td>22</td>
<td>1 (0.95%)</td>
<td>1 (1.3%)</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>104 (100%)</td>
<td>77 (100%)</td>
<td>181</td>
</tr>
</tbody>
</table>

In Table 5.4 an indication is given whether the students in the control group and in the experimental group were repeating a standard or not. Altogether
1.9% of the experimental group were repeating standard seven in 1993 while 98.1% were doing standard seven for the first time. In the control group all the students were attending standard seven for the first time.

**Table 5.4: Composition of Standard Repetition of the two groups**

<table>
<thead>
<tr>
<th>Repeating a standard</th>
<th>Experimental</th>
<th>Control</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2 (1.9%)</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>No</td>
<td>102 (98.1%)</td>
<td>77 (100%)</td>
<td>179</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>104 (100%)</strong></td>
<td><strong>77 (100%)</strong></td>
<td><strong>181</strong></td>
</tr>
</tbody>
</table>

Of the parents of the experimental group 26.9% earned R999.99 and below per month and 23.1% earned between R1000.00 and R1999.99 per month; 30.8% earned between R2000.00 and R2999.99 and 19.2% earned R3000.00 and above per month. In the control group 23.3% earned R999.99 and less, 37.7% earned between R1000.00 and R1999.99, 31.1% earned between R2000.00 and R2999.99 and 7.9% earned above R3000.00. This is depicted in Table 5.5.
Table 5.5: Income Profile of the groups' parents

<table>
<thead>
<tr>
<th>Monthly Income</th>
<th>Experimental</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0 – R999.99</td>
<td>28 (26,9%)</td>
<td>18 (23,3%)</td>
<td>46</td>
</tr>
<tr>
<td>R1000.00 - R1999.00</td>
<td>24 (23,1%)</td>
<td>29 (37,7%)</td>
<td>53</td>
</tr>
<tr>
<td>R2000.00 - R2999.99</td>
<td>32 (30,8%)</td>
<td>24 (31,1%)</td>
<td>56</td>
</tr>
<tr>
<td>R3000.00 upwards</td>
<td>20 (19,2%)</td>
<td>6 (7,9%)</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>104 (100%)</strong></td>
<td><strong>77 (100%)</strong></td>
<td><strong>181</strong></td>
</tr>
</tbody>
</table>

Table 5.6 indicates that in the experimental group 47,1% of the subjects came from married units; 15,4% came from a single parent family with only a father; 26% came from a single parent family with only a mother and 11,5% were under guardians. In the control group 48% of the students came from married family units, 13% from single parent family with only a father; 26% from a single parent family with only a mother while 13% were under guardians.

Table 5.6: Composition of Household of the two groups

<table>
<thead>
<tr>
<th>Nature of household</th>
<th>Experimental</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both parents</td>
<td>49 (47,1%)</td>
<td>37 (48%)</td>
<td>86</td>
</tr>
<tr>
<td>Father</td>
<td>16 (15,4%)</td>
<td>10 (13%)</td>
<td>26</td>
</tr>
<tr>
<td>Mother</td>
<td>27 (26%)</td>
<td>20 (26%)</td>
<td>47</td>
</tr>
<tr>
<td>Guardian</td>
<td>12 (11,5%)</td>
<td>10 (13%)</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100 (100%)</strong></td>
<td><strong>77 (100%)</strong></td>
<td><strong>181</strong></td>
</tr>
</tbody>
</table>
The sibling number of both the experimental group and the control group is depicted in Table 5.7. In the experimental group 17.3% came from a single child family, 58.7% came from two to three sibling homes and 24% came from a home with 4 and more siblings. In the control group 27.3% came from a single sibling home, 50.6% came from a home with two or three siblings while 22.1% came from families with four or more siblings.

Table 5.7: Composition of the number of siblings of the two groups

<table>
<thead>
<tr>
<th>Sibling number</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18 (17.3%)</td>
<td>21 (27.3%)</td>
<td>39</td>
</tr>
<tr>
<td>2-3</td>
<td>61 (58.7%)</td>
<td>39 (50.6%)</td>
<td>100</td>
</tr>
<tr>
<td>4+</td>
<td>25 (24%)</td>
<td>17 (22.1%)</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td><strong>104 (100%)</strong></td>
<td><strong>77 (100%)</strong></td>
<td><strong>181</strong></td>
</tr>
</tbody>
</table>

Of the children in the experimental group 39.4% were first born, 26.9% were last born and 33.7% were middle born. In the control group 44.2% were first born and 31.1% last born and 24.7% were middle born. This information is depicted in Table 5.8.
### Table 5.8: Composition of the birth order of the two groups

<table>
<thead>
<tr>
<th>Birth order</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Born</td>
<td>41 (39.4%)</td>
<td>34 (44.2%)</td>
<td>75</td>
</tr>
<tr>
<td>Last Born</td>
<td>28 (26.9%)</td>
<td>24 (31.1%)</td>
<td>52</td>
</tr>
<tr>
<td>Middle Born</td>
<td>35 (33.7%)</td>
<td>19 (24.7%)</td>
<td>54</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>104 (100%)</td>
<td>77 (100%)</td>
<td>181</td>
</tr>
</tbody>
</table>

Table 5.9 depicts that 43.2% of the experimental group came from the West Rand, 51% from the East Rand, 2.9% from Pretoria and 2.9% from the Vaal Triangle. In the control group 57.1% came from the West Rand, 35.1% came from the East Rand, 2.6% came from Pretoria and 5.2% came from the Vaal Triangle.

### Table 5.9: Composition of Town of origin

<table>
<thead>
<tr>
<th>Town</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Rand</td>
<td>45 (43.2%)</td>
<td>44 (57.1%)</td>
<td>89</td>
</tr>
<tr>
<td>East Rand</td>
<td>51 (51%)</td>
<td>27 (35.1%)</td>
<td>80</td>
</tr>
<tr>
<td>Pretoria</td>
<td>3 (2.9%)</td>
<td>2 (2.6%)</td>
<td>5</td>
</tr>
<tr>
<td>Vaal</td>
<td>3 (2.9%)</td>
<td>4 (5.2%)</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>104 (100%)</td>
<td>77 (100%)</td>
<td>181</td>
</tr>
</tbody>
</table>
5.2.3 INFERENTIAL STATISTICS: A COMPARISON OF THE
CONTROL AND THE EXPERIMENTAL GROUPS

It is important to note that as the year progressed of the 104 of the
experimental group 6 withdrew because of various reasons such as
transportation problems from home to school, subjects were too difficult etc.
as a result the author was left with 98 students (experimental group). The
77 subjects of the control group were available right through the year.

Because the data obtained from the examination is of an internal strength
and because there are two groups involved in this research a student t-test
analysis would have been an appropriate statistical technique to analyse.
However, to link up with the rest of the investigation a Univariate Analysis of
Variance (Anova) of the SPSS programme is used (Nie et al: 1975).

5.2.3.1 Comparing the academic performance of the
experimental and the control groups in 1993 and 1994
respectively

Table 5.10 presents a comparison of the means and standard deviations for
both the experimental group and the control group on the dimension of their
Average Examination marks, as well as English, Science and Mathematics
marks in November 1994.
The author will assess whether the observed differences in respect of the Average Examination marks, Mathematics marks, English marks and Science marks between the control and the experimental groups are statistically significant or not. The following null hypothesis and its alternative are formulated.

**NULL HYPOTHESIS**

There are no statistically significant differences between the mean sub-scale scores for the control group and the experimental group in respect of the Average Examination marks, English marks, Science marks and Mathematics marks, in November 1994. Observed differences are merely incidental.

**HYPOTHESIS**

There are statistically significant differences between the mean sub-scale scores for the control group and the experimental group in respect of the Average Examination marks, English marks, Science marks and Mathematics marks in November 1994.

The average result of the two groups is compared. The mean score in the English marks is 54,8% for the experimental group as compared to 50,7%
for the control group. For Mathematics it is 56,1% and 45,8% for the experimental and the control groups respectively. For Science the mean score is 52,4% and 47,9% for the experimental and the control groups respectively.

Finally the Average mark mean is 56,1% for the experimental group as compared to 50% of the control group. Table 5.10 depicts the Univariate analysis of this data. The means for the experimental group show consistently higher performance scores than do the means of the control group. Based upon this information as depicted in Table 5.10 it will now be considered whether Technology Education brought about an improvement in the overall students' performance or not.

Results reflected in Table 5.10 provide data that is statistically significant on the:

- Average Examination marks \( (E (1,173) = 17.16 \ p < 0.05 \ \text{critical value} \ 3.89) \);
- English marks \( (E (1.173) = 6.62 \ p < 0.05 \ \text{critical value} \ 3.89) \);
- Mathematics marks \( (E (1.173 = 25.72 <0.05 \ \text{critical value} \ 3.89) \); and
- Science marks \( (E (1,173) = 7.27 \ p <0.05 \ \text{critical value} \ 3.89) \).

The obtained F values for all four marks (dimensions) can, therefore are
rejected and the respective alternative hypothesis can be accepted. Seeing that the children with lower academic performance were those who did not get Technology Education tuition (control group) the author concluded that those students who received Technology Education tuition had statistically significant higher scores than the comparison group as measured by the four sub-scores of the examination.

This shows a marked improvement in the average percentage of each subject and in the average of each student, thus indicating that Technology Education does not only improve problem solving and decision making skills of students but also contributes towards their performance in Mathematics and Science. One can argue that this is brought about by the interrelated nature of Technology Education to both Science and Mathematics. Remember Technology Education is a subject on its own but borrows and is interrelated to Mathematics and Science, and both these subjects do borrow from Technology Education and are interrelated to it.

Table 5.11 provides a Univariate Analysis of the experimental and control group marks and the two groups are comparable and there are no statistically significant differences between the four sub-marks of the two groups in the November 1993 examination, in respect of:

- Average Examination score \( F(1.179) = 0.53 \) p < 0.05 critical value 3.91;
• English ($F (1.179) = 0.95 \ p < 0.05 \ critical \ value \ 3.91$); 

• Mathematics ($F (1.179) = 0.24 \ p < 0.05 \ critical \ value \ 3.91$); and 

• Science ($F (1.179) = 0.038 \ p < 0.05 \ critical \ value \ 3.91$).

Therefore, there are no statistical significant differences between the two groups, the only difference is observed in the November 1994 examination.

Tables 5.10, 5.12 and Table 5.13 give further information.
Table 5.10: Descriptive statistics and Univariate analysis of variance comparing the November 1994 marks of the experimental group and the control group in respect of the average examination marks, English, Mathematics and Science marks

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>EXPERIMENTAL</th>
<th>CONTROL GROUP</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>CRITICAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>F</td>
<td>d/f</td>
<td>P</td>
</tr>
<tr>
<td>AVERAGE EXAM</td>
<td>98</td>
<td>56.1</td>
<td>10.44</td>
<td>77</td>
<td>50</td>
<td>8.40</td>
<td>17.16</td>
<td>1.173</td>
<td>.000*</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>98</td>
<td>54.8</td>
<td>11.91</td>
<td>77</td>
<td>50.7</td>
<td>8.31</td>
<td>6.62</td>
<td>1.173</td>
<td>.000*</td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>98</td>
<td>56.1</td>
<td>16.94</td>
<td>77</td>
<td>45.8</td>
<td>5.89</td>
<td>25.72</td>
<td>1.173</td>
<td>.000*</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>98</td>
<td>52.4</td>
<td>12.36</td>
<td>77</td>
<td>47.9</td>
<td>8.60</td>
<td>7.27</td>
<td>1.173</td>
<td>.000*</td>
</tr>
</tbody>
</table>

* P < 0.05

The underlined scores refer to the group with the higher mean on each sub-scale.
Table 5.11: Descriptive statistics and Univariate analysis of variance comparing the average examination marks, English, Mathematics and Science marks in November 1993 of the experimental and control groups.

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>EXPERIMENTAL</th>
<th>CONTROL GROUP</th>
<th>F</th>
<th>df</th>
<th>p</th>
<th>CRITICAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>N</td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>AVERAGE EXAM</td>
<td>104</td>
<td>52.1</td>
<td>16.27</td>
<td>77</td>
<td>53.5</td>
<td>6.61</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>104</td>
<td>51.1</td>
<td>12.12</td>
<td>77</td>
<td>52.5</td>
<td>7.32</td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>104</td>
<td>48.5</td>
<td>9.27</td>
<td>77</td>
<td>47.8</td>
<td>9.67</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>104</td>
<td>49.5</td>
<td>16.84</td>
<td>77</td>
<td>49</td>
<td>8.94</td>
</tr>
</tbody>
</table>

* P < 0.05

The underlined scores refer to the group with the higher mean on each sub-scale.
5.2.3.2 Comparing the academic performance of the experimental group in 1993 and 1994 respectively

The following null hypothesis and its alternative is formulated.

**NULL HYPOTHESIS 2** There are no statistically significant differences between the mean sub-scale scores for the experimental group in November 1993 as compared to those in November 1994 in respect of the Average Examination marks, Science marks, English marks and Mathematics marks. Observed differences are merely incidental.

**HYPOTHESIS 2** There are statistically significant differences between the mean sub-scale score for the experimental group in November 1993 as compared to those in November 1994 in respect of the Average Examination marks, English marks, Science marks and Mathematics marks.

On the basis of data in table 5.12 one observes that on all four sub-scores there are observable statistically significant differences in respect of
• Average Examination marks ($F(1,200) = 4.21 \ p < 0.05 \ critical \ value \ 3.04$), ;

• English ($F(1,200) = 4.97 \ p < 0.05 \ critical \ value \ 3.04$);

• Mathematics ($F(1,200) = 15.67 \ p < 0.05 \ critical \ value \ 3.04$); and

• Science ($F(1,200) = 3.93 < 0.05 \ critical \ value \ 3.04$).

$F$ values for all four dimensions are statistically significant at the 5% level of significance. The null hypothesis for the four dimensions can, therefore be rejected at the 5% level of significance and the respective alternative hypothesis for the four dimensions can be accepted. This shows a markedly improved performance of the experimental group when comparing 1993 and 1994.
Table 5.12: Descriptive statistics and Univariate analysis of variance comparing the November 1993 and the November 1994 marks of the experimental group in respect of the average examination marks, English, Mathematics and Science marks

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>NOVEMBER 1993</th>
<th>NOVEMBER 1994</th>
<th>F</th>
<th>d/f</th>
<th>P</th>
<th>CRITICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>N</td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>AVERAGE EXAM</td>
<td>104</td>
<td>52.1</td>
<td>16.27</td>
<td>98</td>
<td>56.1</td>
<td>10.44</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>104</td>
<td>51.1</td>
<td>12.12</td>
<td>98</td>
<td>54.8</td>
<td>11.91</td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>104</td>
<td>48.5</td>
<td>9.27</td>
<td>98</td>
<td>56.1</td>
<td>16.94</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>104</td>
<td>49.5</td>
<td>16.84</td>
<td>98</td>
<td>52.4</td>
<td>12.36</td>
</tr>
</tbody>
</table>

* P < 0.05

The underlined scores refer to the group with the higher mean on each sub-scale.
5.2.3.3 Comparing the academic performance of the control group in 1993 and 1994 respectively

The following null hypothesis and its alternative is generated.

**NULL HYPOTHESIS 3** The control group sub-scores in the Average Examination mark, English, Mathematics and Science are not the same for the November 1993 as compared to November 1994. Any observed positive comparison is merely incidental.

**HYPOTHESIS 3** The control group sub-scores in the Average Examination mark, English, Mathematics and Science are the same for the November 1993 as compared to November 1994.

On the basis of data presented in Table 5.13 it can be observed that on all four sub-scores there are no statistically significant differences in respect of 1993 November and 1994 November compared.

- Average examination score $= (F (1, 152) = 3.05 \ p < 0.05 < \text{critical value } 3.91)$;
- Mathematics $(F (1, 152) = 2.40 \ p < 0.05 \text{ critical value } 3.91)$;
• English \( (F(1,152) = 0.68 \ p< 0.05 \ \text{critical value 3.91}) \); and
• Science \( (F(1,152) = 2.17 \ p< 0.05 \ \text{critical value 3.91}) \).

The obtained F values for all four dimensions are statistically significant at the 5% level of significance. The null hypothesis for all four dimensions can, therefore be rejected and the respective alternative hypothesis can be accepted. This shows stability in the scores of the control group after a year of tuition.
Table 5.13: Descriptive statistics and Univariate analysis of variance comparing the November 1993 and the November 1994 marks of the control group in respect of the average examination marks, English marks, Mathematics marks and Science marks

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>NOVEMBER 1993</th>
<th>NOVEMBER 1994</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>N</td>
<td>M</td>
<td>S</td>
<td>F</td>
<td>d/f</td>
<td>P</td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>77</td>
<td>47.8</td>
<td>9.67</td>
<td>77</td>
<td>45.8</td>
<td>5.89</td>
<td>2.40</td>
<td>1,152</td>
<td>0.000*</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>77</td>
<td>52.5</td>
<td>8.94</td>
<td>77</td>
<td>50.7</td>
<td>8.31</td>
<td>0.68</td>
<td>1,152</td>
<td>0.000*</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>77</td>
<td>49</td>
<td>7.32</td>
<td>77</td>
<td>47.9</td>
<td>8.60</td>
<td>2.17</td>
<td>1,152</td>
<td>0.000*</td>
</tr>
<tr>
<td>AVERAGE EXAM</td>
<td>77</td>
<td>53.5</td>
<td>6.61</td>
<td>77</td>
<td>50</td>
<td>3.40</td>
<td>3.05</td>
<td>1,152</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* P < 0.05

The underlined scores refer to the group with the higher mean on each sub-scale.
5.3 DISCUSSION OF RESULTS

5.3.1 TECHNOLOGY EDUCATION ENHANCES PERFORMANCE IN MATHEMATICS, SCIENCE AND ENGLISH

Results of this study support literature related to Hypothesis One, Two and Three that Technology Education “incorporates the analytic approach of Science with the qualitative logic of Mathematics” (Ortega 1995:15) and “integrates the communication skills of language arts” (Froese 1988:88).

Further these results reinforce La-Porte and Sanders' (1993:18) assertion that Technology Education through problem solving activities provides practical, meaningful and motivating learning content for Science and Mathematics teachers.

It also reinforces the assertion that “it is through integrated curricula experiences that children begin to see learning as a related whole rather than a meaningless fragmentation of subjects or skills” (Goodman, Smith, Meredith and Goodman 1987:374). Co-ordinating Technology Education activities with Mathematics and Science teaching can be used to reinforce learning that takes place in Mathematics and Science classrooms.
Emanating from Table 5.10 the author concludes that Technology Education improved performance of the experimental group in the area of Science, Mathematics, English and the overall performance. Table 5.11 shows that the performance of the two groups was almost the same in November 1993 with no statistically significant differences, on the other hand Table 5.10 indicates a statistically significance difference between the experimental and the control group marks in November 1994 after the experimental group received tuition in Technology Education. Further statistical information about the experimental group is presented in Table 5.12. According to Table 5.13 there is no statistically significant difference between the scores of the control group in November 1993 and in November 1994

The dynamics of the experimental group show a marked improvement in the average percentage of each subject and in the overall average of each student, thus indicating that Technology Education does not only improve problem solving and decision making skills of students but also improves their performance in Mathematics and Science. One can also argue that this is brought about by the interrelated nature of Technology Education to both Science and Mathematics. Note that Technology Education is a subject on its own but borrows and is interrelated to Mathematics and Science, both these subjects do borrow from Technology Education and are interrelated to it.
5.3.2 TECHNOLOGY EDUCATION ENHANCES THE OVERALL PERFORMANCE OF STUDENTS

It is very important to note that the results of the pilot study as depicted in Table 5.10 as mentioned in 5.3.1 indicate that Technology Education when taught in conjunction with Mathematics, Science, English and other school subjects in a standard 8, class considerably improves student overall performance.

Interviews held with parents of the experimental group throughout the year indicated that there was an improved performance in their children. Children gave more attention to their homework especially in Mathematics. More time was spent on working on their projects during weekends and their attitude towards school was reported as markedly improved. These children held more talks about their teachers and the school with the parents and had shown a lot of pride in their homework. Parents also indicated a markedly improved parent involvement and communicated regularly with the school. Parents also indicated an interest in Technology Education.

Previous teachers of these students, in an informal session observed an improvement in the students' work tempo and according to them the students' reasoning ability and perception of problems was of an outstanding nature. Teachers who were engaged with these students during the year also observed a
difference in the students' work performance as compared to when they first came to school. Their attitude towards work also dramatically improved and they developed more and more pride in the schoolwork.

5.4 CONCLUSION

Finally, there are certain conclusions that emanate from both the descriptive statistics and inferential statistics, namely students who received tuition in Technology Education are more likely to improve their overall performance and they are likely to perform better in Mathematics and Science as well as in English as compared to their counterparts who did not receive tuition in Technology Education. Because this study is a pilot, further studies need to be undertaken to attest the above-mentioned conclusions.
CHAPTER 6 - SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

The purpose of this study was:

(a) to give the background of Technology Education as a subject to show how diverse it is in different countries and to link Technology Education with Technology as its basis.

(b) (i) to formulate broad guidelines for teaching Technology Education in the further education and training phase. These guidelines include the role of the teacher in Technology Education, the Technology Education programme and Technology Education activities.

(ii) to formulate broad guidelines for Technology Education teaching methods. These Technology Education teaching methods include problem solving, the design process, decision-making, integrative teaching, group and self-activity projects and the use of the multimedia.

(iii) to formulate guidelines for assessing a Technology Education programme and the adaptation thereof for the South African context.
(iv) to generate and evaluate a model upon which Science, Mathematics and Technology Education could be presented in an integrated form and to provide an evaluation of this integrated approach.

(c) (i) to compare the level of academic performance of standard 8 students in a pilot study who received tuition in Technology Education with those who did not receive tuition in Technology Education.

(ii) to compare the level of academic performance in December 1993 to those of December 1994 after students in the pilot study have received Technology Education tuition.

(iii) to relate the teaching of Technology Education to Science and Mathematics so as to determine the influence Technology Education had on the performance in Mathematics and Science when comparing the control and the experimental groups in the pilot study.

In the pilot project academic performance was measured by the normal end of the year examination as set out in the different schools.

An experimental group of 98 students from the East Rand, the West Rand, the Vaal Triangle and Pretoria areas was involved. This group received tuition in Technology Education for the whole year together with other
normal science package school subjects. These are tabulated as a form of objectives in appendix II. A curriculum for standard 8 is presented in appendix IV and a list of topics is also presented. A control group of 77 students from the above-mentioned areas was also involved. The control group received no Technology Education tuition but also received tuition in the science package school subjects for the whole year.

6.2 FINDINGS

6.2.1 FINDINGS FROM LITERATURE

6.2.1.1 Findings about Technology

FINDING 1 Technology is a body of knowledge and actions about applying resources, developing, producing, using, assessing and extending the human potential, controlling and modifying the environment (See 2.1).

FINDING 2 The U.S. is perceived to be on the leading edge in biotechnology, electronic systems and software and in Europe Technology is increasingly acquiring a strategic relevance for political independence, economic development and social welfare. Japan, on the other hand, holds the power on consumer electronics, semiconductors, low cost manufacturing techniques and a few other areas (See 2.2).
FINDING 3  Developing countries are presented with generic technologies at different times, at different stages of the development of their economies as well as at different stages of the global socio-economic system (See 2.3).

FINDING 4  For developing countries to acquire proficiency in Technology it is important that an awareness of different generic technologies available in the world be generated. At the same time developing countries should also be aware of different ways in which new Technology can affect infrastructure and raw materials in a developing country (See 2.4).

FINDING 5  There is a general belief that the applications of and involvement in Technology marginalize women. This is not the case and should not be the case. Technology should strive towards equality to all boys and girls (2.4.1).

FINDING 6  Technology has an impact on the refinement and development of raw materials, energy needs, nature of waste products and the generation of heat. Technology should be adapted to an organisational structure of a
developing country in which it will be manifested, alternatively the country’s infrastructure should be adapted to new technologies (See 2.4.2).

**FINDING 7**

It is imperative that developing countries should be aware of the fact that different technologies may or may not have answers to local questions of some of the troubling and value matter of developing countries. Importation of new technologies should always be treated with absolute carefulness (2.4.3).

**FINDING 8**

In adopting new foreign technologies, developing countries should be aware of the technologies link with local technology emanating from local infrastructure (See 2.4.4).

**FINDING 9**

Technology acquisition should be seen as part of a broader societal dialogue in which potential stakeholders in developing countries should be consulted (See 2.4.5).

**FINDING 10**

In countries with an inadequate creative or adaptive capacity for pursuing an autonomous policy in Technological development, the policy of Technological
development should be based on importing foreign Technology (See 2.5).

**FINDING 11** The globalization of markets, emerging technologies and the privatisation of production are world tendencies that explain the interest of governments and enterprises in the question of international competitiveness (See 2.6.).

**6.2.1.2 Findings about Technology Education**

**FINDING 12** Technology Education strives towards giving individuals an understanding of the role that technical resources play in solving problems and addressing needs as well as an understanding of how organisational strategies utilise Technology whether simple or complex. It empowers individuals to control or at least to work effectively with their environment (See 3.1).

**FINDING 13** Technology Education should develop in all students an understanding and appreciation of technological processes and products and the impact these developments have on our lives. It should provide
challenges to all populations in schools and recognise
the difference in talents, purposes and potentialities of
all students (See 3.2).

**FINDING 14**

Technology Education should enable learners to learn
how to locate information and how to develop lifelong
capabilities enabling them to reach decisions by
making value judgements resulting from rational
actions in gathering, analysing and interpreting data
pursuant to the problem prior to making a decision.

Technology Education is a means of enabling students
to live and function in the 21st century parallel to
technological advances (See 3.3).

**FINDING 15**

The following themes and content could be covered by
Technology Education:

- agriculture and food products;
- management of resources;
- medical science and health care;
- transportation;
- information technology;
- materials;
- industrial products; and
- construction (also See 3.3).
FINDING 16  Technological literacy is a subset of basic literacy. It is a concept raised to describe the extent to which an individual understands and is capable of using Technology. The structure of Technological literacy is based upon knowledge and the ability to use and communicate technological systems, ideas and words (See 3.4).

FINDING 17  Implementation of Technology Education into schools involves a set of behaviours, which extends far beyond the school environment. It involves the implementation of a new culture characterised by the creation of new products or modifying existing ones (See 3.5).

FINDING 18  It is assumed that Technology Education as part of the school experience for all pupils irrespective of gender, develops technological skills. The approach of Technology Education should show no significant differences between male and female pupils. It should include education appropriate to both boys and girls (3.6).

FINDING 19  The Technology 2005 project envisages that by the year 2005 Technology Education will be part of the
education of every boy, girl, teacher and learner in South Africa (See 3.7).

6.2.1.3 Findings about guidelines for teaching Technology Education

FINDING 20 Technology Education should provide first hand practical experiences as a means of gaining understanding of concepts. It is the application of resources to solve problems and extend human potential (See 4.1.1).

FINDING 21 Technology Education activities should be safe, have high learning potential, concentrate on the process and not the product, should have low cost, use Technology that is user friendly and stress the active in the activity (See 4.1.2).

FINDING 22 The teacher is central to a good Technology Education programme and should display enthusiasm for the content, the students and the school. The Technology Education teacher should stay up to date and offer a co-ordinated approach to teaching by integrating themes from various school subjects in Technology Education.
The following are five predominant teaching methods in Technology Education:

- problem solving;
- design process;
- decision making;
- integrative teaching; and
- group and self activity projects

Multimedia as an approach to the teaching of Technology Education is an alternative that can assist students to understand various themes and concepts in Technology Education (See 4.2).

Technology Education assessment standards should enhance the overall quality of the curriculum content, the instructional programme, the teaching methods, the physical environment of Technology Education students and the awareness of parents of the Technology Education programme (See 4.4.1).

Findings about the integrative teaching of Technology Education, Mathematics and Science

Technology Education integrates the analytic approach of Science with the qualitative logic of Mathematics. Such integration improves student participation in
Science and Mathematics over the course of the year. (See 4.4.2).

**FINDING 26** Although Technology Education knowledge has existed far longer than scientific knowledge, the acquiring of technological inventions and innovations did not rely upon scientific theory for their development. Science and Mathematics undergirds technological development (See 4.4.3).

**FINDING 27** Technology Education problem solving enables Mathematics and Science curricula to have its subject matter to be within the context of the real world, thus enabling Science and Mathematics principles learned to be applied to the real world setting (See 4.4).

### 6.2.2 FINDINGS FROM THE EMPIRICAL RESEARCH

A Univariate Analysis of Variance (Anova) was used to test the three main hypotheses at an alpha level of 0.05. The Anova analysed the scores of the standard 8 students who received a year tuition in Technology Education and the standard 8 students who did not receive tuition in Technology Education over the same year. Performance in Science, Mathematics and English was measured with the normal end of the year testing procedure at each school.
FINDING 28
Statistically significant differences were found between the academic performance of these two groups of students for the Average Examination mark, English, Mathematics and Science marks. This implied that students who received tuition in Technology Education performed better than students who did not receive tuition in Technology Education in areas of Science, English and Mathematics. Their average examination marks were also better than those of students who did not receive tuition in Technology Education.

FINDING 29
A statistically significant difference was found between the November 1993 marks and the November 1994 marks in the Average Examination mark, English, Science and Mathematics marks of the experimental group. This is also an indication that Technology Education enhanced academic performance in Mathematics, Science and English, as well as overall performance.

FINDING 30
In the group that received no Technology Education tuition no significant statistical differences were found in the Mathematics, English, Science and the Average Examination marks. The performance of the control
group stayed almost the same with regard to the above-mentioned subjects.

6.3 CONCLUSIONS AND IMPLICATIONS

Based on the revelation of literature review in Chapter two, three and four the author is convinced that a curriculum in Technology Education is a must at the further education and training phase. This study also reveals that Technology Education is universally acceptable and it is a school subject presented in both developed and developing countries. Accordingly, South Africa, like all other developing countries, should also adapt to Technological advancement. The advancement of Technology can only be facilitated by incorporating a Technology Education curriculum in the South African schools, and by using the correct guidelines and assessment standards in Technology Education. The teaching of Technology Education should be evaluated by an integrated approach.

From the review of literature the author can deduce that for South Africa to develop technologically, South Africa should look at developing countries which are at par with South Africa in terms of development. The adaptation of these countries' curriculum to South African conditions may be beneficial to South Africa.

The analysis of data in Chapter 5 reveals that students who undertake Technology Education as part of their school package improve considerably
in their overall school performance. Furthermore Technology Education enhances performance in Science and Mathematics. Data reveals that Technology Education also enhances and promotes performance in the subject English. Data in chapter 5 reveals that students who undertake Technology Education, improved their performance in Science, Mathematics and English.

The analysis of data also reveals that students who undertake Technology Education as a subject perform better in Mathematics, Science and English than their counterparts who do not receive Technology Education as part of the package.

6.4 RECOMMENDATIONS

6.4.1 RECOMMENDATIONS FOR RESEARCH

RECOMMENDATION 1 Training of national research personnel must be given preferential treatment. Priority should be given to Science, Mathematics and Technology Education. However a balance between the Humanities and Technology Education should be struck.

RECOMMENDATION 2 National research bodies must be established or strengthened and endowed with sufficient
manpower and financial resources to enable them to adapt and assimilate imported Technology and to design and produce new Technology.

**RECOMMENDATION 3** National education research bodies should help to design and produce teaching materials so that education matters fully reflect real local conditions.

**RECOMMENDATION 4** South Africa should use all possible materials and human resources to develop a Technology Education programme on its own.

**RECOMMENDATION 5** A sense of creativity and innovation must be developed in all educational establishments and settings for students and teachers as a means of enhancing proficiency in Technology.

**RECOMMENDATION 6** An education policy should be developed along the lines that will ensure proper national economic development and the provision of qualified staff.
RECOMMENDATION 7
The general educational policy of the country should enhance the adoption of a suitable Technology Education policy, adapted to South African conditions.

RECOMMENDATION 8
The education policy should aim towards improving South Africa's ability to assimilate, adapt and modify imported technologies and to produce new technologies by herself rather than importing Technology from other countries. The provision of the Technology 2005 project should also be incorporated.

RECOMMENDATION 9
The present South African educational policy should also continue to take local conditions into account and include a design and research component at the university level as a means of implementing a rigorous and an appropriate policy of Technology development.

RECOMMENDATION 10
The South African education policy should continue bringing about important developments in the extension of Mathematics, Science and Technology Education.
6.4.2 RECOMMENDATIONS FOR TECHNOLOGY EDUCATION

RECOMMENDATION 11  Universities should be adequately equip-ped for designing, assimilating and dis-seminating Technology Education through teacher education, including in-service training.

RECOMMENDATION 12  The Technology Education development policy must take into account the role of the present education system in shaping the general education matters in South Africa.

RECOMMENDATION 13  Education and training should not be isolated from the process of technological development and adaptation of imported Technology.

RECOMMENDATION 14  Technology Education curricula should cover the constant changes that occur in industry under the influence of imported technologies.

RECOMMENDATION 15  The subject Technology Education should be established in all the South African schools as recommended by the Technology 2005 project.
It should be initiated from the general education and training phase up to the higher education and training phase. This system should extend education along more practical lines and give educators the tools that will enable them to change the environment.

**RECOMMENDATION 16** There should be collaboration between schools and enterprises so as to guide training to meet the needs of individuals, society and the enterprises. This training should be based on curricula designed in co-operation with the enterprises concerned. This gives an indication and an opportunity to study the type of Technology peculiar to a particular enterprise.

**RECOMMENDATION 17** The following guidelines can be followed in extending Science and Technology Education:

- Students in the further education and training phase should be motivated to opt for Mathematics and Science;
- enrolment in the Sciences and Humanities should be balanced;
- students should be motivated to enrol in Technology Education; and
- universities should be encouraged to lay more emphasis on the training of engineers, technicians, agronomists, public workers and post and telecommunications engineers.

RECOMMENDATION 18 Teachers should be retrained in the teaching of Technology Education, Mathematics and Science with emphasis on minority teachers.

RECOMMENDATION 19 Technology Education should accommodate all students across gender lines and it should also accommodate the handicapped. Technology Education should be offered to both rural and urban students.

RECOMMENDATION 20 The Technology Education policy as prescribed in the Technology 2005 project should be continuously revisited for purification and improvement.
RECOMMENDATION 21 Technology Education should not be taught in isolation but an integrated approach should be undertaken and Technology Education should be approached in its context and relationship to other sciences.

RECOMMENDATION 22 South African curriculum planners should be sensitised about the necessity of Technology Education in the mainstream education curriculum.

RECOMMENDATION 23 Ongoing empirical research in all areas of Technology Education especially teaching strategies needs to be conducted in order to contribute to the almost non-existent body of literature on Technology Education in South Africa.

6.5 LIMITATIONS OF THE STUDY

Although the author explored various literatures relating to Technology Education activities, the author is of the opinion that more could be done in the formulation of these activities. More activities could be researched. The applicability of these activities can also be further studied. Technology
Education teaching methods mentioned in Chapter 4 are not the absolute. The author is of the opinion that more methods are available and could be explored. These methods mentioned in Chapter four are but broad guidelines. Multimedia is perceived differently in different circles, therefore more deliberation should be made about this aspect to give more clarity.

Assessment standards are an important area in any field of study including Technology Education. The author is of the opinion that more work can be done in exploring these assessment standards for Technology Education.

Researchers are always faced with the dilemma of separating between integrating Technology Education, Science and Mathematics, and the delivery approach in which a single teacher teaches Science, Mathematics and Technology as a subject in a single classroom. More can be done in clarifying this issue.

As the pilot study is an experimental study, there might have been more control and manipulation over the experimental group resulting in the improvement in overall academic performance and not Technology Education. The experimental study is actually a pilot study that could generate further studies.

It was also very difficult to minimise the impacts of Halo Effects. The results can only be generalised to populations from which the sample was selected, results cannot be generalised in a broader sense to all students.
Some subjects could not be located as they withdrew from the study. Some vital information may have been lost. However an effort was undertaken to ensure that maximum information is retained.

The end of the year examination may not have been standardised as each school had its own standard of examining academic performance at the end of the year. All the examination papers in English, Science and Mathematics were however moderated by the author.

6.6 SUMMARY

Technology Education is a new dawn for South African Schools. It is a means that will facilitate interest and motivation in Mathematics and Science. More can still be done in this area, especially in South Africa. This study is but one of the means that facilitates the infiltration of Technology Education into the mainstream subjects in South Africa.
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APPENDIX I - BIOGRAPHICAL INFORMATION

YOUR RESPONSES ARE STRICTLY CONFIDENTIAL. THEY ARE FOR SCHOOL RECORD PURPOSES ONLY. YOU ARE REQUESTED TO PROVIDE RESPONSES TO THE FOLLOWING QUESTIONS. PLEASE TICK A POSSIBLE ANSWER IN THIS FASHION [✓]. WHERE NECESSARY SUPPLY THE INFORMATION.

1. WHAT IS THE RACE OF YOUR CHILD?
   [ ] BLACK
   [ ] COLOURED
   [ ] WHITE
   [ ] OTHER RACE

2. WHAT IS THE GENDER OF YOUR CHILD?
   [ ] MALE
   [ ] FEMALE

3. HOW OLD IS YOUR CHILD?
   [ ] give age please

4. WAS YOUR CHILD REPEATING STANDARD SEVEN?
   [ ] YES
   [ ] NO
5. WHAT IS THE NATURE OF YOUR FAMILY?
[ ] BOTH PARENTS
[ ] FATHER
[ ] MOTHER
[ ] GUARDIAN

6. HOW MANY CHILDREN DO YOU HAVE?
[ ] 1
[ ] 2-3
[ ] 4+

7. WHAT IS THE BIRTH ORDER OF YOUR CHILD?
[ ] FIRST BORN
[ ] LAST BORN
[ ] MIDDLE BORN

8. WHERE IS YOUR FAMILY STAYING?
[ ] WEST RAND
[ ] EAST RAND
[ ] PRETORIA
[ ] VAAL

THANK YOU VERY MUCH FOR SUPPLYING THE INFORMATION.
APPENDIX II - OBJECTIVES ORGANIZED FROM HIGHEST TO LOWEST MEAN

<table>
<thead>
<tr>
<th>OBJECTIVE</th>
<th>MEAN</th>
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<tbody>
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<td>The students should be able to:</td>
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<td>Describe the concept Technology and its principles.</td>
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</tr>
<tr>
<td>Describe the importance of Technology in life.</td>
<td>6.59</td>
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<td>Value being technologically literate.</td>
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<td>Describe problems related to Technology.</td>
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<td>Apply technological solutions to problems.</td>
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<td>1.17</td>
</tr>
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<td>Apply tools, materials and processes associated with Technology.</td>
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<td>Safely apply Technology tools, process and materials.</td>
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<td>Apply Technology innovation in production.</td>
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<td>Apply computer use in Technology.</td>
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<td>Describe the role of Technology in shaping the future.</td>
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<td>Locate information regarding Technology and its impacts.</td>
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</tr>
<tr>
<td>Describe human technological action towards the environment.</td>
<td>5.80</td>
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<tr>
<td>Describe potential ecologically sound technological applications.</td>
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<td>Improve environmental quality.</td>
<td>5.77</td>
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<td>Describe conflicts in the use of earth resources.</td>
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<td>Describe influence on human decision making.</td>
<td>5.73</td>
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<td>Know entrepreneurship and marketing.</td>
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NB: SD is standard deviation
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<td>Transistor</td>
<td>Transmitter</td>
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<td>Ultrasound</td>
<td>Union</td>
<td>Uplink</td>
<td>Vehicle</td>
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<td>Video-conference</td>
<td>Voltage</td>
<td>Wavelength</td>
<td>Word Processor</td>
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### APPENDIX IV: TECHNOLOGY EDUCATION CURRICULUM FOR STANDARD EIGHT

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<tr>
<th>TERM</th>
<th>TOPIC IN CURRICULUM</th>
<th>MODULE</th>
<th>DESCRIPTION</th>
<th>COMPETENCIES</th>
<th>SESSION</th>
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</thead>
</table>
| 1    | • Mechanical tools.  
• Mechanical basic skills.  
• Safety.  
• Ergonomics – visual components at the disposal of the designer. | The scientific calculator | An assembly based project used for the introduction of Technology for the higher grades.  
After completion of assembly, the pupils use their own calculator in their math, science and Technology lessons. | • Investigating what Technology is all about.  
• Assembling a calculator according to given instructions, with emphasis on technological considerations such as ergonomics, the importance of understanding and following instructions, safety etc.  
• Using basic technological tools. | 6       |
|      | • The use of hand tools (soldering iron, side cutter, desoldering pump, wire stripper, etc.)  
• Safety regulations.  
• First aid in a technological environment.  
• Quality and reliability assurance. | Basic tool skills      | A module developed for creating awareness of safety considerations when using tools.  
During this module the pupils practice their skills in assembling a plug and creating an ornament. | • Using the proper tool for a specific assignment.  
• Developing awareness towards the ergonomics of the tools. | 8       |
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<tr>
<th>TERM</th>
<th>TOPIC IN CURRICULUM</th>
<th>MODULE</th>
<th>DESCRIPTION</th>
<th>COMPETENCIES</th>
<th>SESSION</th>
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<tbody>
<tr>
<td></td>
<td>A marble in a cage – an ornament</td>
<td>A module whereby the pupils exercise their skills in using tools and soldering to create (design make and evaluate) an ornament.</td>
<td>• Stripping, cutting and soldering according to the given instructions using the appropriate tools. • After the completion of this assignment the pupil designs, makes and evaluates his own ornament.</td>
<td>28</td>
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<tr>
<td></td>
<td>The plug</td>
<td>The plug is one of the most common components in the home apparatus. This module deals with the operation of the plug, how to assemble it and discusses some safety regulations.</td>
<td>• Assembling a plug. • Safety precautions. • Practice in using the correct tools. • Getting to know international standard of plugs.</td>
<td>28</td>
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<td>2,3</td>
<td>• Stages in the production of a product. • Electrical and electronics instrumentation and measurements in electrical circuits (power supply, digital multimeter, and energy storage). • Electrostatics, voltage and current.</td>
<td>The flashing lights</td>
<td>This project is used as an introduction to electrostatics; basic principles in electrostatics, electricity and electronics. The Technology process (from the identification of the problem through the specifications, choosing an optimal solution, the design (partly), making, evaluating and marketing the product</td>
<td>• Conducting a market research. • Experimenting with electrostatics and simple electrical circuits such as oscillators, charging/discharging circuits. • Designing (partly) and making a Z1 decorative flashing lights product (implementing skills such</td>
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<tr>
<td>TERM</td>
<td>TOPIC IN CURRICULUM</td>
<td>MODULE</td>
<td>DESCRIPTION</td>
<td>COMPETENCIES</td>
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<td></td>
<td>• Ohm's law.</td>
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<td>is served as the back-bone of this module.</td>
<td>• Experimenting with and operating electrical components such as resistors, LED's, capacitors, IC's etc.</td>
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<td></td>
<td>• Electrical circuits, the need approach.</td>
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<td>• Aesthetics of the product.</td>
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<td></td>
<td>• Digital electronics (NOT gate).</td>
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<td>• Entrepreneurship and marketing skills.</td>
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<td>• Switching (oscillation).</td>
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<td></td>
<td>• Quality and reliability assurance.</td>
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<td></td>
<td>• Ergonomics.</td>
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<td>4</td>
<td>• Basic computer skills.</td>
<td></td>
<td>The pupils use the MS Word in order to write his report on the Flashing Lights project.</td>
<td>• Explaining basic concepts of computers (memory-RAM, ROM, accessories etc.).</td>
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<td></td>
<td>• Word-processor.</td>
<td>Basic computer skills MS Word</td>
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<td>• Writing a report on MS Word.</td>
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<td>• Saving, retrieving and printing a document.</td>
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<td>• Using tables and graphics.</td>
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<tr>
<td>TOPICS IN THE TECHNOLOGY EDUCATION CURRICULUM</td>
<td>PROJECT-BASED ACTIVITY</td>
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<tr>
<td>1. INSTRUMENTATION MEASUREMENT AND BASIC MEASUREMENT</td>
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<tr>
<td>1.1 ELECTRICAL AND ELECTRONIC INSTRUMENTATION AND MEASUREMENT</td>
<td>BIOLOGY CELL</td>
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<tr>
<td>1.1.1 POWER SUPPLY, OSCILLOSCOPE, SIGNAL GENERATOR, DIGITAL MULTIMETER</td>
<td>FLASHING LIGHTS</td>
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<td>1.1.2 MEASUREMENTS IN ELECTRICAL CIRCUITS</td>
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<td>1.2 MECHANICAL MEASUREMENT INSTRUMENTATION</td>
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<td>COMPASS, VERNIER, RULER</td>
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<td>1.3 ELECTRICAL AND ELECTRONIC TOOLS</td>
<td>FLASHING LIGHTS</td>
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<tr>
<td>SOLDERING IRON, SIDE-CUTTER, DESOLDERING PUMP, LONGNOSE PLIER, WIRE STRIPPER, WIRE-WRAP</td>
<td>WATER PURIFICATION</td>
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<td>1.4 MECHANICAL TOOLS</td>
<td>PLASTIC MATERIALS</td>
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<tr>
<td>HAMMER, HACKSAW, VICES, VICE-GRIP, SCRIBER, CENTRE PUNCH, TWIST DRILL, SQUARE, KNIFE, FILES AND RIVET GUN</td>
<td>TABLE ORNAMENT</td>
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<td>SOLDERING, WIRING, USING SIMULATION SOFTWARE FOR P.C. BOARDS EDITING, WIRE-WRAP</td>
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<td>THE USE OF HAND TOOLS, MARKING OUT, CUTTING OUT AND SAWING, LINE BENDING, DRILLING, JOINING OR GLUING, WARMING, PLASTIC FORMING AND FINISHING TECHNIQUES</td>
<td>CAR PARK</td>
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<td>2. THE USE OF DATA SHEETS</td>
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<td>LOCATION OF A COMPONENT, IDENTIFYING THE CHARACTERISTIC OF THE COMPONENT, FINDING AN EQUIVALENT</td>
<td>CAR PARK</td>
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<td>3. THE USE OF TECHNICAL SPECIFICATION</td>
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<td>COMPARISON OF EQUIPMENT BY USING THEIR RESPECTIVE TECHNICAL SPECIFICATIONS AND CHOOSING THE MOST SUITABLE ONE WHILE CONSIDERING NEEDS AND LIMITATIONS</td>
<td>CAR PARK</td>
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<td>4. FIRST AID AND SAFETY</td>
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<td>FIRST AID</td>
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5. MATERIALS

5.1.1 NATURAL MATERIALS (I.E. WOOD, STONE)
5.1.2 ARTIFICIAL MATERIALS
   (A) POLYMERS (I.E. THERMOPLASTIC, THERMOSTATIC)
   (B) METALLIC MATERIALS (I.E. FERROUS, NON-FERROUS)
5.1.3 CERAMIC MATERIALS (I.E. GLASS AND PORCELAIN)
5.1.4 COMPOSITE MATERIALS.

5.2 CRITERIA IN CHOOSING MATERIALS

5.2.1 PHYSICAL PROPERTIES (I.E. SPECIFIC WEIGHT, MELTING POINT, MAGNETISM, HEAT, CONDUCTIVITY, ELECTRICAL CONDUCTIVITY)
5.2.2 CHEMICAL PROPERTIES (I.E. CORROSION, HEAT DURABILITY, CHEMICAL DURABILITY)
5.2.3 MECHANICAL PROPERTIES (I.E. ELASTICITY, PLASTICITY, HARDNESS, TENSILE STRENGTH)
5.2.4 TECHNOLOGICAL PROPERTIES (I.E. MACHINABILITY, DUCTILITY, PLIABILITY, MALLEABILITY)
5.2.5 ECONOMICAL CONSIDERATION (I.E. PRICE, AVAILABILITY)
5.2.6 RECYCLING OF MATERIALS – AS A TECHNOLOGICAL PROBLEM, ECONOMICAL, SOCIAL AND ECOLOGICAL

6. ENERGY AND ITS TRANSFORMATION

6.1 ENERGY SOURCES
   (A) VOLATILE (GAS, PETROL, COAL)
   (B) NON-VOLATILE (NUCLEAR ENERGY, SOLAR ENERGY)
6.2 DIFFERENT FORMS OF ENERGY AND ITS TRANSFORMATION IN TECHNOLOGICAL SYSTEMS (I.E. MECHANICAL, CHEMICAL AND ELECTRICAL)
6.3 ENERGY ACCUMULATION
   THE NEEDS, THE POSSIBILITIES AND THE LIMITATIONS
6.4 TRANSPORTATION – EMISSION, CONVECTION AND CONDUCTION – TECHNOLOGICAL SOLUTIONS
6.5 ENERGY AT HOME AND IN THE INDUSTRY
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<tr>
<td>• BASIC IDEAS IN OPERATING A COMPUTER</td>
<td>CAR PARK</td>
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<td>• WORD-PROCESSOR</td>
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<td>8.1 ELECTROSTATICS, ELECTRICAL FIELD, VOLTAGE AND CURRENT</td>
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<td>8.2 &quot;OHMS' LAW, CHIRCOFF'S LAW</td>
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<td>8.3 ELECTRICAL CIRCUITS (SERIES, PARALLEL AND COMBINED)</td>
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<td>8.4 POWER AND EFFICIENCY</td>
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<td>9. CONTROL SYSTEMS – BASIC PRINCIPLES</td>
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<td>9.1 HUMAN, ECONOMIC AND SOCIAL CONTROL SYSTEMS</td>
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<td>9.2 BLOCK DIAGRAM OF A CONTROL SYSTEM</td>
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<td>9.3 OPEN LOOP, AND CLOSED LOOP</td>
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<td>9.4 LINEAR CONTROL SYSTEM AND &quot;ON/OFF&quot; CONTROL SYSTEM</td>
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<td>9.5 THE &quot;FEED-BACK&quot; IN THE CONTROL SYSTEM</td>
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<td>9.6 THE STABILITY OF THE SYSTEM</td>
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<tr>
<td>10.1.1 TRANSDUCERS, LIGHT, TEMPERATURE, PRESSURE, HUMIDITY, VOLUME</td>
<td>CAR PARK</td>
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<td>10.1.2 ACTUATORS; RELAYS, MOTORS, LEAD, MICROPHONE, LOUDSPEAKER</td>
<td>BIOLOGY CELL</td>
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<td>10.2 PERIODICAL SIGNALS – LINEAR, NON-LINEAR</td>
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<td>10.3 GAIN (POWER, VOLTAGE, CURRENT)</td>
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<td>10.4 SERVO AMPLIFIER; IN OPEN LOOP, IN CLOSED LOOP, (AS A COMPARATOR, SUMMER AND DERIVATOR)</td>
<td>FLASHING LIGHTS</td>
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<td>10.5 TRANSISTOR AS AN AMPLIFIER AND AS A SWITCH</td>
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<td>10.6 THE DIODE AS A SWITCH AND AS A RECTIFIER</td>
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<td>TOPICS IN THE TECHNOLOGY EDUCATION CURRICULUM</td>
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<td>11. DIGITAL ELECTRONICS</td>
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<td>11.1 NUMBER SYSTEMS</td>
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<td>11.4 COMBINATIONAL SYSTEMS (ADDER, SUBTRACTER, MULTIPLEXER, COMPARATOR, DECODER)</td>
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<td>11.5 COUNTERS, OSCILLATORS AND MEMORIES</td>
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<td>12. MECHANICAL ENGINEERING</td>
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<td>12.1 LOADING AND THE ABILITY TO SUSTAIN LOAD</td>
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<td>12.2 DEFORMATION DUE TO TIME FACTOR</td>
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<td>12.3 TYPES OF LOADING AND DEFORMATIONS</td>
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<td>TENSION AND COMPRESSION</td>
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<td>SHEERING</td>
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<td>TORSION</td>
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<td>BENDING</td>
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<td>THE BREAKING STRESS</td>
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<td>12.4 THE DETERMINATION OF THE STRENGTH OF MATERIALS</td>
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<td>THE BEHAVIOR OF MATERIALS UNDER LOAD</td>
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<td>12.5 HOOK'S LAW, TENSION DIAGRAM, ELASTICITY AND PLASTICITY RANGE</td>
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<td>12.6 SAFETY (MARGINS) COEFFICIENT AND CALCULATIONS IN THE DESIGN AND STRENGTH OF MATERIAL CALCULATIONS</td>
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<td>12.7 MECHANICAL COMPONENTS – IMPLEMENTATION OF STRENGTH OF MATERIALS CALCULATIONS</td>
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<td>12.8 MECHANICAL MECHANISM; TRANSFER OF FORCE</td>
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<td>12.9 LEVERAGE AND GEARS</td>
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<td>12.10 INCLINED PLANE AND SCREWS</td>
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<td>12.11 GEAR TRAINS</td>
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<td>12.12 FLEXIBLE FORCE TRANSFER SYSTEMS</td>
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<td>12.13 PNEUMATIC SYSTEMS: COMPRESSOR, ACTUATORS, VALVES</td>
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<td>12.14 HYDRAULIC SYSTEMS: PUMPS, ACTUATORS, VALVES</td>
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<td>12.15 THE USE OF STANDARDS</td>
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<td>13. INDUSTRY IN A TECHNOLOGICAL SOCIETY</td>
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