Measuring pupil's knowledge and understanding of Technology: a methodological study

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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ABSTRACT

Technological literacy is a competency that is widely espoused both locally and internationally (UNESCO, 1984; TAAP, 1991). Technological literacy has been described as a multi-dimensional construct consisting of a knowledge, skills and an affective component. This study investigated learner performance in the cognitive domain. Intact classes of Foundation (Grade 3), Intermediate (Grade 6) and Senior phase (Grade 9) learners from 12 Western Cape schools participated in a standardised paper-and-pencil assessment, the Pupil's Understanding of Technology (PUT) test.

The study attempted to measure the effect of two variables - geographic location and gender, on learner knowledge and understanding of technology. The main substantive findings to emerge are firstly that geographic location is significantly related to performance in specific content areas of technology. Secondly, gender appears to be less significant in determining learner knowledge of technology on most questions. Furthermore, the level of knowledge of technology appears to correspond with phase or developmental level, thus supporting the conception of technological knowledge as a subset of general achievement.

In addition, this study describes various methodological limitations pertaining to the PUT format and content. The main methodological limitations to an assessment of learner knowledge and understanding of technology using the PUT instrument relates to the nature of technological knowledge, and the understanding that technological literacy is a complex, multi-dimensional and activity-based subject. The study further highlights the need for an interrogation of the monolithic categories of 'geographic location' and 'socio-economic' category.

OPSOMMING

Tegnologiese geletterdheid is 'n vaardigheid wat beide nasionaal en internasionaal voorgestaan word (UNESCO, 1984; TAAP, 1991). Tegnologiese geletterheid is al beskryf as 'n multi-dimensionele konstruk wat bestaan uit 'n kennis, vaardigheid en emosionele komponent. Die studie ondersoek die leerder se prestasie in die kognitiewe gebied. Volledige groepe van Grondslag (Graad 3), Intermediêre (Graad 6) en Senior fase (Graad 9) leerders van 12 skole in die Wes-Kaap het deelgeneem aan 'n gestandardiseerde pen-en-papier evaluering, die Leerling se Begrip van Tegnologie (Pupil's Understanding of Technology - PUT) toets.

Die studie poog om die effek van twee veranderlikes, geografiese ligging en geslag, op die leerder se kennis en begrip van tegnologie te meet. Die belangrikste substantiewe bevindinge is eerstens dat geografiese ligging beduidend korreleer met prestasie in spesifieke inhoudelike areas van tegnologie. Tweedens blyk dit dat geslag 'n minder belangrike invloed toon in die bepaling van die leerder se kennis van tegnologie in die meeste vrae. Verder blyk dit dat die vlak van kennis van tegnologie ooreenstem met die fase of ontwikkelingsvlak. Dit ondersteun die konsepsie van tegnologiese kennis as 'n onderafdeling van algemene prestasie.

Hierdie studie beskryf ook verder die verskeie metodologiese beperkinge wat betrekking het op die PUT uitleg en inhoud. Die belangrikste metodologiese beperkinge vir die evaluering van leerderkennis en begrip van tegnologie met die PUT verwys na die aard van tegnologiese kennis, en die opvatting dat tegnologiese geletterdheid 'n komplekse, multi-dimensionele en aktiwiteitsgebaseerde onderwerp is. Dit blyk ook verder uit die studie dat daar 'n behoefte is aan 'n ondersoek na die monolitiese kategorieë van 'geografiese ligging' en 'sosio-ekonomiese' afdeling.

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ACRONYMS AND ABBREVIATIONS

C2005	Curriculum 2005
CEPD	Centre for Education Policy Development
CUMSA	Curriculum model for South Africa
DACST	Department of Arts, Culture, Science and Technology
DOE	Department of Education
EMS	Economic and Management Sciences
IEB	Independent Examinations Board
GET	General Education and Training
ITEA	International Technology Education Association
LAC	Learning Area Committee
PTT	Provincial Task Team
OBE	Outcomes-based Education
PATT	Pupil's Attitude towards Technology
TAAP	Technology for all Americans
PUT	Pupil's Understanding of Technology
T2005	Technology 2005

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CHAPTER 1
INTRODUCTION

1.1. Introduction

Technological literacy is a competency, which is widely espoused both locally and internationally. It has also been adopted as a primary aim of most technology curricula. Indeed, it is so highly valued, that the incorporation of a technology curriculum into general, mainstream education has been a trend observed in many countries (Layton, D, 1993). This chapter introduces the concept of technological literacy and provides the rationale advanced by the South African government, in particular the Departments of Education (DoE) and of Arts, Culture, Science and Technology (DACST) for promoting this competency. In addition, it briefly describes the methodological limitations to assessing learner knowledge and understanding of technology. Furthermore, it provides a cursory review of factors related to the implementation context that further compound an evaluation of technology curriculum outcomes, specifically learner knowledge and understanding of technology.

1.2. Background to the study

1.2.1. Rationale for the promotion of technological literacy

In the *White Paper on Education and Training* (Department of Education, 1995), the then Minister of Education, Prof. Sibusiso Bengu, articulated an integrated vision for the education and training sectors, which establishes the need for promoting technological literacy as part of the nation's human resource development strategy. He then expands this notion by making the explicit link between the national project to respond to an ever-expanding global economy, which requires new types of organisational arrangements, and the curriculum as the primary vehicle for this strategy.

Successful modern economies require citizens with a strong foundation of general education, the desire and ability to continue to learn, to adapt to and develop new knowledge, skills and technologies. In response to such structural changes in social and economic organisation and technological development, international approaches to education and training are now a major international trend in curriculum development and the reform of qualification structures. (DACST, 1995: 14)

He further contrasts these new modes of organisation with the obsolete forms, which he asserts are based on:

a rigid division between 'academic' and 'applied', 'theory' and 'practice', 'knowledge' and 'skills', 'head' and 'hand'. Such divisions have characterised the organisation of curricula and the distribution of educational opportunity in many countries of the world, including South Africa. They have grown out of, and helped to reproduce, very old occupational and class distinctions. In South Africa, such distinctions in curriculum and career choice have been closely associated in the past with the ethnic structure of economic opportunity and power... (DACST, 1995: 14)

To counter-act the divisive effects of such curricula, the policy seeks to develop:

An appropriate mathematics, science and technology education initiative to stem the waste of talent, and make up the chronic national deficit in these fields of learning, which are crucial to human understanding and economic advancement. (DACST, 1995: 16)

The social goals which the policy seeks to establish, are aimed at redressing educational legacies in the distribution of education and training in South Africa by:

> *Providing 'access to technological and professional careers requiring a strong basis in mathematics and science, (which has been) denied to all but a fraction of the age cohort, largely because of the chronic inadequacy of teaching in these subjects'.*
>
> *Redressing the historic gender imbalance by promoting high levels of participation of women in higher education and in sustaining these levels in their professional lives, in these fields. (DACST, 1995: 16)*

1.2.2. Rationale for the inclusion of technology in the S.A. national curriculum framework

The new national curriculum framework places considerable emphasis on *relevance* (CEPD, 2000). In it, it is stated that the curriculum should be "relevant and appropriate to current and anticipated future needs of the individual, society, commerce and industry." In addition, there is considerable attention given to economic growth in a competitive international economic system. This hinges fundamentally on a well educated population equipped with the relevant skills needed by the economy at a given point in time, and who possess the ability to continue learning, developing and acquiring new competencies. The inclusion of Technology within the C2005 framework is considered to be an important attempt at making the curriculum compatible to the skills needs of a globalised economy. To illustrate, C2005 has specific outcomes for each learning area, including outcomes for Technology. The *National Assessment Policy in the GET band, Grade R-9 and ABET* (1998), defines specific outcomes as 'what learners are capable of knowing and doing at the end of a learning experience' (pg 12). The following examples are illustrative:

- Specific outcome three for the Technology learning area is premised on the assumption that in the rapidly changing economic arena the flow of information is vast, and learners should be competent and confident in working with and responding to this information.
- Specific outcomes five and six attempt to focus learners on a critique of technology and its repercussions for the social, cultural and economic fabric of society.

Furthermore, the outcomes specified in C2005 for Technology also incorporate work-related competencies. As such, they are geared toward the skill needs of post-fordist production in an internationally competitive market. The outcomes specified for the Technology learning area are thus an attempt at balancing the twin imperatives of global economic competitiveness and growth on the one hand with equity, social and economic development on the other.

1.2.2.1. The introduction of Technology as a component of general education in South Africa

C2005 is based on a progressive, outcomes-based pedagogy. It incorporates eight mandatory learning areas (integrated disciplines), one of which is Technology. As the previous curriculum (Nated Report 550), contained no precedent for technology, the National Department of Education perceived a need to develop the capacity of educators in delivering technology education, and of provinces in supporting the delivery of a technology education curriculum, ahead of official timeframes for the introduction of C2005. Under the auspices of HEDCOM, a research and development project called *Technology 2005* (T2005) was launched in 1995, with a mandate to:

- establish a Technology Education Forum;
- gain support for Technology as a learning area;

- develop an S.A-relevant understanding of Technology;
- develop an S.A-relevant curriculum and materials;
- structure pre-service and in-service training;
- develop provincial infrastructure and expertise;
- develop a national strategic plan for implementation within the C2005 framework.

In addition, the following structures were instituted to ensure that T2005 is capacitated to deliver its mandate:

- In April 1996, the T2005 National Task Team was established.
- In addition, provincial education departments received grants for the appointment of full-time staff over the projected three-year life span of the T2005 project.
- By May 1996, the T2005 team had developed a draft curriculum framework document for Technology, two months ahead of the official announcement of C2005, with Technology as a distinct learning area.
- In 1997, T2005 Provincial Task Teams (PTTs) were set up in some provinces (although all provinces were initially targeted). The main task following the establishment of these provincial structures for T2005, was the training of PTT members and the development and trial of learning support materials. By early the next year, materials were ready to be trialled. An evaluation of learning support materials for Technology, and of training for provincial project teams was conducted in 1997.
- In 1998, 100 schools were selected to be part of a national pilot for implementing Technology (called the 100 school Technology project) as a new learning area. Pilot schools were trained in three provinces (Western Cape, Kwa-Zulu Natal and Gauteng) using the T2005 materials. An evaluation of the implementation of Technology in the pilot schools was also conducted in 1998.

Although historical accounts of the introduction of Technology education in South Africa trace its origins back to the early 1980s when provincial departments conceived of the need for Technology in the curriculum, it was not until the early nineties that the idea of introducing Technology as part of the National curriculum was first conceived. A characteristic feature of this development relates to the disparate perspectives on the appropriate curriculum implementation model/approach to the introduction of Technology, which surfaced as early as 1992. Whereas the previous National Department of Education in its curriculum model for South Africa (CUMSA) propagated the view that Technology should be a separate subject, the CEPD advocated an integrated Science and Technology approach. After intense lobbying from various groups, the Heads of Education Committee (HEDCOM), decided in 1994 to set up a pilot project to trial the introduction of Technology as a school subject. But developments relating to C2005 resulted in a lack of attention to this critical aspect of the identity of Technology in the curriculum. In July 1996, the National Department of Education, to the exclusion of the T2005 team, announced that Technology would be introduced as a distinct learning area. Due to pressure resulting from the eminent introduction of C2005, provincial capacity (from the PTTs) in support of the development and trial of learning support materials for the Technology learning area shifted to support of C2005, and its newly established structures, e.g. the LACs, including the Technology LAC, which operated independently of the T2005 task team. Thus due to factors relating directly to the pace and scope of introduction of C2005, curriculum design and policy around Technology have been severely compromised, resulting in a lack of consensus on the appropriate content structure and instructional methodology for Technology in the curriculum.

1.2.3. Recent developments with regard to Technology in the curriculum

The implementation of C2005 has been fraught with problems from flaws in the structure and design of the curriculum, to problems with the scope and pace of curriculum implementation. In May 2000, the minister of Education announced the findings of the ministerial committee commissioned to review C2005 and its implementation. The Committee proposed general improvements described as, 'essential to robust implementation of curriculum change'. These pertain to:

- the structure and design of the curriculum
- training, orientation and development of teachers
- learning support materials
- national, provincial and district-level support of curriculum processes
- the pace and scope of implementation with reference to grades 4 and 8 (to begin implementation in 2001).

Whilst these recommendations are of importance to all learning areas, the Review Committee also released very specific recommendations for the Technology learning area. With regard to Technology, the C2005 Review Committee proposed the following changes:

<u>Review Committee Recommendation 1</u>*:* Drop Technology as it currently stands (i.e. as a separate subject), link the design component of Technology to the Life Orientation learning area, and merge Technology and Science. The rationale for this decision is that because Technology is an emerging learning area the content and conceptual boundaries are not yet as neatly drawn as they are in the more established school subjects, so that their distinctiveness from other learning areas is not easily apparent to teachers. Due to the curriculum design problem of under specification of content,

educators would not know what to teach, especially where themes such as Entrepreneurship are common to EMS in the lower grades and to Life Orientation and Technology in the higher Grades. This could lead to unnecessary repetition.

Review Committee Recommendation 2: Train science educators to teach technology. This recommendation is based on a belief that given the dearth of expertise in technology, science educators could be easily trained to apply their knowledge of science to Technology.

In response to this recommendation, the Technology Association of South Africa has argued inter alia, that:

> *While we are not totally opposed to linking Technology to Science, we believe that this will relegate Technology to a minor role in the curriculum. (Randewijk, J, 2001: 7)*

In addition, international commentators like Dyrenfurth (1991) echo this sentiment:

> *One of the unfortunate characteristics of the South African education policy scene... appears to be a key mistake in terms of its conceptualisation of what is needed to generate competitive technological literate people at all levels of educational accomplishment. The essential nature of this accomplishment is that of blind faith. The belief is that Science and Maths curricula will provide the understandings and capabilities necessary to achieve Technological Literacy and capability. This is a bankrupt belief based on tradition and lack of understanding of the fundamental nature of Technology (which is not applied science)... Technology is a discipline with a knowledge structure and a set of processes that distinguishes it from Science and Mathematics. Therefore there is no more reason to conclude that Science and Mathematics study will necessarily lead to technological proficiency and understanding than there is to*

conclude that the study of Maths will lead necessarily lead to Music or Art proficiency and understanding. (Pg 25)

The Western Cape Provincial Learning Area Committee (WCPLAC) for Technology, with the endorsement of the S.A. Technology Association, strongly advocated the retention of Technology as a separate learning area within C2005, expressing the following concerns:

> *The Revised Curriculum 2005 will be designed to take South Africa into the 21st Century. It is ironical however, that given the challenges South Africa faces with respect to nation-building, the economy, housing, crime, etc. this curriculum ignores the vital role Technology education can play in contributing to the development of the country... The Report advocates a high knowledge and a high skills curriculum as a means to promote social justice, equity and development. Surely by denying the majority of learners (unfortunately it is those in rural and impoverished areas that will be hardest hit) the opportunity to experience Technology education and EMS, flies in the face of the rationale for the Revised Curriculum 2005. (Randewijk, J, 2001: 1).*

The Association recommended that:

- Technology (and EMS) be reinstated, but in a streamlined form to avoid curriculum overload;
- The curriculum accommodate for CORE and ELECTIVES, within Technology Education, such that schools with fewer resources can at least cover the minimum Technology curriculum content (the 'core').

- Instructional ('notional') time be reallocated, giving preference to the gateway learning areas (Literacy and Numeracy), and distributing the remaining time equally amongst the remaining six learning areas.

Technology was ultimately reinstated as a separate subject.

This brief history serves to highlight the nature of Technology in the South African National Curriculum, and the debates that have besieged it since its early introduction. Whilst it is in part a reflection of flaws in the structure and design of C2005, it also points to a lack of definition on the level of policy as to precisely how Technology should be accommodated in the curriculum.

1.3. Defining technological literacy

Internationally, technology education policy documents assert the primary goal of a technology curriculum to be the attainment of technological literacy (TAAP, 1991; UNESCO, 1984). Technological literacy is understood to be comprised of three components: - technological knowledge and understanding; technological capability; and the understanding/awareness of the interrelationship between technology and society. Dyrenfurth and Kozak (1991) describe technological literacy as '... a multidimensional term that includes the ability to use technology (the practical dimension), the ability to understand the issues raised by or use of technology (the civic dimension), and the appreciation for the significance of technology (the cultural dimension)' (1991:7). Jones (1996) stress the inter-relatedness of these components, and the necessity of assessing these *holistically* rather than as discrete competencies. Stables (1992) asserts the need for developing '*holistic technological capability*' (1994: 4). Hill (1997) characterises this '*integrated* study of technological processes, knowledge and context' as 'one of the aspects that should distinguish technology education from other program areas that address technological content' (1997: 2).

The authors above suggest that technological activity in the classroom be devised to include all three components. Appropriate assessment would on this conception entail attention to the multi-dimensional nature of technological activity, but also to the integrated nature of these dimensions.

1.4. Statement of the problem

Layton contends that 'the inclusion of Technology as a component of general education poses intriguing problems of curriculum organisation and inter-relationships, to say nothing of content, pedagogy and assessment' (1993: 57). Amongst these problems, Hayden (1989) enunciates that although there is an abundance of methods and techniques for the delivery of technology, and various content models are proposed (and indeed in use), it is difficult to measure the effect of these on pupil's understanding of technology (Hayden, M.A., 1989). He states the problem as follows:

> *The lack of accepted or standardised measures of technological literacy, (a stated goal of the technology curriculum) make it difficult to assess and compare the effect of various forms of instruction in technology education.*

The difficulty of assessing learning is compounded in a subject area such as technology where there is little consensus on the nature of the subject, the nature of classroom activities and no summative assessment structure. For example, Sharpe D.B. (1992) reports that whilst some Canadian states are well underway in transforming their industrial arts curricula (with the focus on constructs such as woodworking, metalworking and drafting) to technology education programmes (which focus on manufacturing construction and transportation), others have not as yet adopted this framework, and as such there exists great diversity in content and emphasis of curricula from state to state, district to district and even within a single school. There is thus likely to be differences in content and methodology emphasis in the delivery of the technology curriculum, which in turn impacts on learner knowledge and understanding of technology.

The result is that disparate approaches to curriculum implementation, which are likely to produce varying outcomes, severely constrain the possibilities of effectively evaluating the effect of the Technology curriculum on learner understandings. Furthermore, given the lack of a summative assessment structure and the injunction that the goals of the technology curriculum be assessed holistically, the evaluation of learning in technology presents a formidable challenge.

1.5. Purpose of the study

The mission and goals of the *Technology 2005* project support the promotion of technological literacy through the curriculum for the General Education and Training band of schooling. Technology is herein defined as:

> *The use of knowledge, skills and resources to meet human needs and wants, and to recognise and solve problems by investigating, designing, developing and evaluating products, processes and systems. (IEB Technology handbook, 1998)*

The purpose of this study is to assess learner knowledge and understanding of specific technological content, and to investigate the effect of possible correlates (geographic location and gender) on learners' knowledge and understanding of Technology. Krathwohl, D. R et al. (1964) identify three categories into which these outcomes can be categorised: cognitive (knowledge and understanding) affective (values and attitudes) and psychomotor (capabilities and competencies) aspects. The aim of this study is to investigate the effect of exposure to the technology curriculum on learner achievement in the *cognitive* domain. The study aims to assess the extent to which performance on the PUT may be attributed to exposure to the Technology curriculum.

1.6. Scope of the study

The study investigated the knowledge and understanding of Technology (PUT) amongst Grade 3, Grade 6 and Grade 9 learners from 8 primary and 4 high schools in the Western Cape. To determine this, the evaluation utilised the PUT instrument, a paper-and-pencil test designed to measure learners' knowledge and understanding of different aspects of technology. Different versions of the PUT were used for the Foundation Phase and Intermediate Phase PUT respectively.

1.7. Structure of this thesis

In this chapter I have detailed the general purpose for, and orientation to the study. Chapter two will review the local and international literature on technological literacy, with a particular focus on issues pertaining to the assessment of technological knowledge. It will in particular focus on the measurement of one dimension of technological literacy, technological knowledge. Chapter three is a detailed description of the methodology, which underpins this study. Chapters four to seven is a separate presentation of the findings for each grade level. The study concludes with Chapter eight, a summary of the main findings.

CHAPTER 2
LITERATURE REVIEW

2.1. Introduction

Internationally, technology education policy documents assert the primary goal of a technology curriculum to be the attainment of technological literacy (TAAP, 1991; UNESCO, 1984). Due to its broad and encompassing nature, technological literacy has defied easy operationalisation, and standardisation for the purposes of assessing it. However, various investigations into the concept of technological literacy have been made. This chapter summarises the main characteristics of technological literacy, and thereby establishes the basis for a critique of assessment as represented by the PUT.

2.2. Technological literacy

Croft (1991) obtained a profile of a technologically literate person by consulting a group of technology experts through a Delphi technique. This profile tended to emphasise ethical decision-making abilities with regard to the use of technology and included; possession of basic literacy skills required to solve technology problems; ability to make wise decisions about uses of technology; ability to apply knowledge, tools and skills for the benefit of society; and, ability to describe the basic technology systems of society. Steffens (1986) asserts that technological literacy involves having the knowledge and understanding of technology and its uses; having skills, including skills in handling tools, as well as the skill in evaluating technology; and, attitudes and values associated with new technologies and their application. Hayden (1989) too conducted a literature review resulting in his definition of technological literacy as 'knowledge and abilities to select and apply appropriate technologies in a given context'.

This characterisation of technology as including higher-level cognitive skills may be viewed as progressive to the extent that modern forms of economic and social organisation require skills that are transferable across a range of emerging technologies and types of social and economic organisation. They do not sufficiently highlight the need for a conception of technological literacy as essentially activity-based, context dependent and domain specific. These additional criteria are what distinguishes technological literacy both from general literacy as well as literacy in other subject areas e.g. scientific literacy.

Three dimensions of technological literacy have been discerned: knowledge, skills and attitudes/values. The following section discusses each of these in turn.

The Knowledge Component

The broad knowledge areas identified in the literature are summarized as follows:

- Knowledge of problems that might have technological solutions. Yff and Butler suggested that a curriculum for technological literacy should include a study of 'the major social, economic, and geophysical problems' (1983: 13). They include among these, such problems as hunger, transportation, and waste disposal.
- Knowledge of important technologies such as computer applications, systems dynamics, industrial processes (Yff & Butler, 1983), biotechnology, materials, and energy technologies (American Association for the Advancement of Science, 1989).
- Understanding of the social and cultural impact of technology such as the effect of technology on societies, its value-ladenness, and its irreversibility (Heinsohn, 1977).
- The range of concepts that are prerequisites for an understanding of technology drawn from such other disciplines as science, mathematics, history, and language (Lewis & Gagel, 1992).

- An understanding of the form or structure of technological knowledge. This implies understanding of knowledge of what works and therefore has a practical dimension. It also implies an appreciation of how technological knowledge is related to other forms of knowledge, particularly science.

Skills Component

Capability, which lies at the heart of technological literacy, is essentially the ability to think and do effectively in the context of the real world. This implies a range of both cognitive and psychomotor skills that Layton has characterized as 'functional competencies' (1987: 25). In addition to those cognitive skills that relate to ways of processing information, the technologically literate persons should display the ability to think critically about technology itself. One concept of technological literacy emphasizes the ability to evaluate technology as one of the core characteristics of the technologically literate person. Donelly described this view as a 'small but important radical strand of thought about technology education' (1992: 133). Lewis and Gagel (1992) suggested that the technologically literate person should "be able to fashion informed opinion regarding the social, political, environmental, or economic consequences" (1992: 131) of technological activity. In the same vein, Yff and Butler (1983) postulated that the most important aspect of technological is that "it should enable citizens to recognize when others, to whom they have entrusted the management of their social institutions, are not acting in their interests" (p. 14).

Engaging in technological activity is an important aspect of capability, and one that involves a complex interaction of cognitive and manipulative skills. Schwaller (1989) identified some of the cognitive ones as analytical thinking, creativity, problem solving, research, and analysis. The manipulative skills are those involved in the design process and in the making of technological products. Design skills are central to technological activity. These skills must be broadly conceptualised to include the abilities to recognize those problems that might yield to technological solutions, generate ideas, and formulate strategies for implementing ideas.

The Affective Component

Layton (1991) argued for a component called technological capability. This refers to a willingness that must precede action in a technological or any other context. Kozolanka and Olson (1994) extended this component to the realm of virtue when they suggested there also needs to be the capacity to act for the right reasons. The profound and pervasive impact of technology on society makes this a critical issue. These relate to the question of social responsibility. The technologically literate person could be expected to exhibit not a mere awareness of, but a concern for, the 'moral and ethical implications of technological choice' (Lewis & Gagel, 1992: 130). As this study focuses on learner knowledge and understanding of technology, the following section discusses the knowledge component of technological literacy in greater depth.

2.3. The knowledge component of technological literacy

2.3.1. The nature of technological knowledge

Lewis and Gagel (1992) argue that literacy implies knowledge, and thus that any definition of technological literacy should encompass a knowledge dimension. They further specify that levels of knowledge correlate with levels of literacy. There is a strong belief among technology educators that technology has its own knowledge and structure just like other school subjects such as mathematics or physics and that this should constitute the basis for its separate disciplinary status (DeVore, 1968, 1992; Erekson, 1992; Savage and Sterry, 1990; Lewis and Gagel, 1992; Waetjen, 1993 and Dugger, 1998). In contrast to this view, Prime (1991) argues that technology certainly embodies a certain kind of knowledge, but that this is a qualified form of knowledge. She states that technological knowledge may have the appearance of a formal discipline, but does not have a clearly generalisable, representative structure characterizing all of technology, as one finds in physics, biology or economics. Technological knowledge acquires form and purpose in specific human activity and the character of technological knowledge is defined by its use. Efficiency, rather than understanding is its objective (Layton, 1974; McGinn, 1978; 1989; Parayil, 1991; Perrin, 1990; Skolimowski, 1972). Technology does utilise formal knowledge such as that found in the sciences and mathematics, but it does so selectively and in response to specific applications. Technology also includes its own abstractions (concepts, theories, rules, and maxims) but again, these are grounded in practical application. A considerable proportion of technological knowledge is however tacit and thus difficult to codify and generalize. The form as well as the complexity of technological knowledge is related to the kind and level of technological activity. Isolated from activity and removed from the implementing context, much of technological knowledge loses its meaning and identity. The defining characteristic of technological knowledge therefore is its relationship to activity. Although technological knowledge is considered to have its own abstract concepts, theories, and rules, as well as its own structure and dynamics of change, these are essentially applications to real situations. Technological knowledge arises from, and is embedded in human activity, in contrast to scientific knowledge, for example, which is an expression of the physical world and its phenomena.

As Landies (1980) observes, while technological processes may be intellectual, the process itself concerns the manner of doing things. It is through activity that technological knowledge is defined and it is activity that establishes and determines the framework within which technological knowledge is generated and used. Because of the link with specific activity, technological knowledge cannot be easily categorized and codified as in the case of scientific knowledge. Technology best finds expression through the specific application of knowledge and technique to particular technological activities. Skolimowski (1972), for example, suggests that thinking technologically cannot be a universal. He asserts that 'specific branches of technology condition specific modes of thinking' (1972: 46). Although technology makes use of formal knowledge its application is interdisciplinary and specific to particular activities.

2.3.2. Types of technological knowledge

Technological knowledge has been classified into two types – procedural (process) and conceptual (content) knowledge. Both types are said to be pivotal to the development of technological literacy. The following section describes the form which each of these take in the context of learning about technology. As the learning outcomes in technology education involve both knowing and doing, procedural and conceptual aspects are equally important.

2.3.2.1. Procedural knowledge

Procedural knowledge is developed through the creation of a process, as when a solution to a particular need or brief is sought. There are a range of these processes which are utilized in the development of technology and therefore may also be appropriate in teaching and learning technology, the two most common being *design* and *problem solving*. The following section addresses each of these in turn.

2.3.2.1.1. Technological problem-solving

The development of problem solving abilities is pivotal to technological literacy. Problem solving is said to be a critical thinking skill necessary for addressing issues related to technology and for developing effective solutions to practical problems. According to the *Rationale and Structure for the Study of Technology* technologically literate persons 'are capable problem solvers who consider technological issues from different points of view and in relationship to a variety of contexts' (ITEA, 1998: 11). Waetjen (1989) described problem solving as an important skill necessary for ensuring technological innovation and for developing technological literacy. Regardless of the rationale put forward for encouraging this competency, problem solving is considered a critical skill for all functional citizens. Problem solving has also become a major theme in technology education and key pedagogical strategy in technology education (Waetjen, 1989). Barnes (1982) concluded that problem solving should be a key descriptor for defining technology as a subject and a curricular organizer for the study of technology. Technological problem solving can be divided into three categories: design, troubleshooting, and technology assessment (impact evaluation).

- *Designing* may be defined as proactive problem solving (Baker & Dugger, 1986). It includes not only the refinement of the original concept but also the research, experimentation, and development necessary to prepare the product for production. Innovating, creativity, and designing are closely related.
- *Troubleshooting*, or reactive problem solving (Baker & Dugger, 1986), involves the recognition that technology encompasses more than innovation. The production and utilization of technical solutions is also a valid source of course content for technology education. Finding and correcting problems during the production or utilization of technical solutions is troubleshooting. Technicians can be satisfied with abilities in design and/or troubleshooting. However, technologists must add the ability to critically *analyze* the impacts of technical solutions in order to predict possible outcomes and choose the most appropriate solution to a problem. Of course, they must also re-evaluate existing solutions. Most practitioners in the field

agree that evaluating the impacts of technology is an important part of technology education. However, finding a way to integrate impact evaluation into a program can be difficult.

Through participation in practical problem solving activities, learners are exposed to technical knowledge as well as higher-order cognitive skills. One difficulty in investigating problem solving behaviour is the many usages of the phrase 'problem solving'. McCormick (1990) noted that, depending on the context, 'problem solving' may mean: (a) a teaching method that encourages active learning, (b) a generic ability to deal with problem situations, (c) a method used in such subjects as mathematics or science, or (d) an empirical investigation. Further, the scientific method of hypothesis generating and testing is also at the heart of technological problem solving. As the concern in this thesis is with technological problem-solving rather than with the more generic types, the following section reviews the major influences on technological problem solving, as well as details some problem solving models in use in technology education. Savage and Sterry (1991) identify technological problem solving processes as having largely originated in the work of Dewey (1910) and Polya (1957). Dewey, they assert, described a five step iterative process of problem solving that comprised: (a) felt difficulty, (b) clarification of the problem, (c) identification of possible solutions, (d) testing the suggested solutions, and (e) verification of the results. Polya (1957) proposed a heuristic process for solving problems in mathematics that provided a guide for action. The steps in Polya's heuristic included: (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back -- checking the results and evaluating the solution. Two additional influences on technological problem solving have been the scientific method and the idea of creative problem solving. DeVore, Horton, and Lawson (1989) added two additional phases: motivation and manipulation. These constitute the basis for the proliferation of problem-solving models, at various levels of complexity. Highly structured approaches often miss the whole point of creative problem solving.

Pucel (1992) espoused problem solving as a technological method, where technology evolves to serve useful purposes of humans, based on processes of innovation. DeLuca (1992) identified several problem-solving processes applied to technology. These processes are troubleshooting/debugging, scientific process, design process, research and development, and project management. Savage & Sterry (1990) proposed a problem-solving model with the premise that humans depend on technical means for survival. They indicated that the problem solving process parallels the scientific method in science. In *Standards for Technological Literacy: Content for the Study of Technology,* problem solving is defined as, 'the process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem to meet a human need or want' (ITEA, 2000: 255). However, as is the case in scientific problem solving, there is no one way in which problem-solving occurs, rather it depends on both the task and context.

Problem solving has been investigated in terms of thinking skills and critical activities. Halfin (1973) identified key mental processes used by technological professionals. They include defining the problem or opportunity, interpreting data, constructing models and prototypes, designing, testing, modelling, creating, and managing. Hill (1997) used definitions and examples developed from Halfin's mental processes to develop and field-test a tool for assessing students during technology education activities. The assessment tool was used to capture qualitative data concerning what mental processes were evidenced in duration and frequency during a modular instructional activity. MacPherson (1998) explored factors affecting another form of technological problem solving, near transfer troubleshooting. He developed a rubric to assess critical incidents in various stages of problem solving activities associated with maintenance activities performed by technicians. This rubric contained critical incidents on a continuum from novice to expert levels. Findings indicated that novices and experts exhibited different patterns of behaviour.

The outcomes of creative problem solving activities depend on the creative processes and ideation techniques that are learned and applied. Furthermore, there are attitudinal (interest, motivation, and confidence), cognitive (knowledge, memory, and thinking skills), and experiential (familiarity with content, context, and strategies) factors that influence problem solving processes (Fisher, 1990).

2.3.2.1.2. Implications of technological problem-solving for instruction in technology

Various ways of emphasizing (creative) problem solving in a learning environment have been suggested (Grabinger, 1996, p. 665; Dooley, 1997). A common feature of these approaches is to place pupils in the midst of a realistic, ill-defined, complex, and meaningful problem, with no obvious or 'correct' solution. Pupils act as professionals in small groups and confront problems as they occur, with no absolute boundaries, insufficient information, and a need to settle on the best possible solution by a given date. In other words, learning is authentic (Lafer & Markert, 1994) in that it involves real-world problem solving situations, is self-directed and reflective. This kind of problem-centred approach empowers the pupils to take responsibility for their learning by allowing them to define what they need to learn and to identify the resources needed. The teacher's role is that of a facilitator in the learning process.

Sellwood (1991), De Luca (1993) and Williams and Williams (1997) argued that creative problem-solving activities are an integral part of technology education, in contrast to instruction that is a step-by-step process, engaging students in reproducing artefacts in an environment dominated by the teacher. The standard problem solving model called 'the technological method' was proposed by Savage & Sterry (1990). Pucel (1992) later modified this model. His approach calls for identifying a need, developing a solution strategy, producing a solution, modifying that solution, and implementing it. Custer (1995) further developed on this model. He classified types of problem solving activities in terms of complexity and goal clarity. He shows that all problem solving activities are not of equal creative merit. Troubleshooting is not of the same order of creativity as inventing. Hill (1997) also contributed to this by designing an instrument that could gauge the mental processes that students employed as they solved technological problems.

Also needed are constructivist notions which hold that students may bring uniqueness to how they approach problems. For example, Wu, Custer & Dyrenfurth (1996) explored whether personal style might be a variable in solving problems. McCormick, Murphy & Hennessy (1994) found that students do not solve problems following the traditional steps of design. Science education provides examples of how pedagogical strategies based on constructivism and situated cognition are used to examine problem posing as children do science. For example, Roth (1995) videotaped children as they worked on solutions to engineering structures problems, subsequently analyzing the dialogue employed by them as they worked cooperatively to solve the problems. Similarly, Appleton (1995) studied how students explored the problem space in solving discrepant event problems in science. Both found that students engaged in flexible problem-solving strategies.

2.3.2.1.3. Technological design

The US Standards for Technology Education (ITEA, 1998) identify design as the most common process appropriate to technology education. Because there is a paucity of classroom research, there are few guidelines on how it should be taught. What is quite clear however, is that the process of design is not generalisable. Research, which compares expert designers with the way children do design, shows that the process is very complex and seldom repeated the same way. Both seem to adopt inventive and flexible approaches that are adapted to the situation in which they are working. Individuals also seem to have preferences for how they design. In the design situation where teachers insist on progressing through set stages, students in fact adopt their own strategies in order to get the job done, but ritualistically use the teacher's approach to satisfy assessment demands (Hennessey & McCormick, 1994). For example, Hennessey and McCormick found that the common requirement to sketch four design alternatives to a problem or brief, a student is often interested in only one, and does the others just to satisfy the teacher.

Implicit within technology curricula is the assumption that children are in need of formal classroom experiences in order to negotiate technology problems and arrive at potential solutions to those problems. Thus curricula tend to include information about skills and knowledge (such as determining needs, evaluating, planning, and making) which are believed to support technological activity (Alberta Education, 1996; Department of Education and Science, 1985; National Research Council, 1996). These are furthermore presented in a very structured, often prescriptive way. A common approach in teaching the technology process is to map out a series of steps for students to follow as they make projects. Examples include design-make-appraise (Australian Education Commission, 1994), identify-design-make-evaluate and define problem-ideas-model-test (USA International technology Education Association, 1998). The idea is that this systematic process can be taught and learned by all pupils who can then apply it to subsequent problems or situations. However, research has revealed that neither students nor designers naturally resort to a predetermined process in their work, but that they make up the process as they proceed. It has also been suggested that the outcome of a design, or the solution to a problem, involves more factors than is represented in a sequence of process steps.

The value of design using a range of processes when developing their technological literacy and capability has been pointed out. Technology is such a broad area that a focus on any one process will not provide students with a broad concept of the nature of technology. Learners have preferred learning styles, and utilizing a range of processes in teaching technology will appeal to more students than would the use of a single process. It will also make the teaching of technology more interesting to both students and teachers.

There are many activities in the design process, including evaluation, communication, modelling, generating ideas, research and investigation, producing and documenting. However, if these are prescribed, it is not possible to determine their level of cognitive involvement, as it is essentially a process directed by and centred on the teacher. There has been a shift away from the notion of a prescribed process such as Design-Make-Appraise (Australian Education Council, 1994) to the idea that there is a range of processes in which students are engaged when they do technology.

Constructivist theory describes learning as an active, continuous process whereby learners take information from their environment and construct personal interpretations and meanings based upon prior knowledge and experience (Kozulin, 1998). By this socio-cultural interpretation, learning occurred from both a personal and social context. It follows that individual construction of technological knowledge occurs predominantly in socially interactive settings, through which members of that context share common symbols. (Gergen, 1995; Wertsch, 1991; Vygotsky, 1986). Thus, with regard to instruction in technology, it is recommended that design processes should relate to each learner's real life environment, allowing the learner to make appropriate and meaningful connections, rather than imposing a 'best steps' approach. (Schwarz, 1996; Lehto, 1998; Adams, 1991).

A key principle in the teaching and learning of design is creativity. Hatch (1988) proposes that divergent thinking skills be encouraged over convergent ones and that creativity should not only be tolerated, but rewarded. Thus, procedural knowledge, as one dimension of technological knowledge, is essentially, non-prescriptive and should include opportunities for learners to engage in multiple strategies for reaching solutions. The literature above also indicates the need to reward creativity, and to acknowledge diversity in individual learners' problem-solving styles. But if individual learning styles were to be accommodated when assessing, it would seem to stand in opposition with the aims of traditional tests, which include the need for standardisation.

2.3.2.2. Conceptual knowledge

Although much research into design technology has focused on characterizing procedural knowledge (skills involved in knowing how to do it) and organizing this knowledge into problem solving models (Johnsey, 1995, 1997; Layton, 1993; McCormick, 1996; McCormick, Hennessy, & Murphy, 1993; Roden, 1997), researchers have begun to argue that procedural knowledge is used in combination with conceptual knowledge (understanding relationships among relevant concepts) and strategic knowledge (planning what to do next) to solve practical problems Levinson, Murphy & McCormick, 1997; McCormick, 1996). Less research has focused on children's conceptual knowledge of design technology (Bennett, 1996; Coenen-Van Den Bergh, 1987; Levinson, Murphy, & McCormick, 1997).

As discussed above, the primary distinguishing characteristic of technological knowledge is that it derives from, and finds meaning, in activity. Accordingly, there are a number of implications for curriculum development. First, technological knowledge is most clearly specified when it is linked to specific activity. It is only through technological activity that the use of knowledge is conditioned. Furthermore, because of the tacit nature of much of technology, an abstract treatment of the subject is incomplete without the accompanying activity. Secondly, technology makes extensive use of formal, abstract knowledge, mainly from the sciences and mathematics, but this knowledge does not constitute a discipline because it is primarily a manifestation of the selective use of disciplines.

All three kinds of technological knowledge (descriptive, prescriptive and tacit) are important for instructional purposes. There is a general tendency to underestimate the extent and importance of the tacit dimensions of technological knowledge. But beyond the more easily codified descriptive and prescriptive forms of knowledge that inform technological activity, there is a wide array of subjective and tacit forms which are not as readily communicable, but which, nevertheless, substantially influence how technological activity is carried out. It is difficult to generalize from a technological knowledge domain because of its strong link with a specific kind and level of activity. If technological knowledge is broadly defined, it loses much of its usefulness. When terms like 'technological literacy' or 'technological method' for example, are not associated directly with specific activity they become operationally meaningless from a curriculum development or an assessment point of view. They mean very little outside of the context in which they are applied, and there are few conceptual guidelines for selecting content (Taba, 1962).

2.4. Assessing learners' technological knowledge

Valid assessment should be construct-driven. It is the nature of the construct of technological literacy that should determine the mode and conditions of its assessment. Although 'technological literacy' is a frequently used term, its broad and encompassing nature makes it difficult to define operationally or to attempt to measure. It is clearly difficult to measure a construct if it has no readily agreed upon conceptual boundaries. This accounts for the fact there is no widely accepted standardized instrument suitable for assessing the broader construct of technological literacy. One exception to this would be Hayden (1989), who developed the Industrial Technology Knowledge instrument to measure students' industrial technological literacy. Hayden concluded that there exists a construct of technological literacy that is a subset of general achievement. However, the construct can only be reliably measured by cognitive testing if there are similarities in the curriculum content of industrial technology programs.

For classroom-based assessment, variations on the portfolio method are used to assess learner progress with regard to technological literacy. Daiber, Litherland, & Thode (1991) described the following techniques to assess the technological literacy level of students in a specific technology education course or program: (a) analysis of taped one-on-one and group discussion that have similar topics at the beginning and end of the course, (b) observation of students involvement with problem solving activities, and the results of hand on activities, (c) utilization of paper and pencil exercises in the format of a pre-test / post-test design, and importantly (d) development of a technology achievement test that includes major objectives of the course.

The methods proposed above for the assessment of technological literacy are time consuming and limited to specific curriculum content and concepts. The inability to measure technological literacy as practiced within the broad scope of technology education has led some educators to select measures in the affective domain as an alternative way to assess technological literacy (Bame, Dugger, de Vries, & McBee, 1993; Raat & de Vries, 1986). However, theorists concur that in addition to assessing the attitudes that are believed to be characteristic of a technologically literate person, the assessment will not be complete without an assessment of knowledge and behaviours, also thought to be the characteristics of a technologically literate person.

Technological literacy has been defined as an outcome measure: that is, it comes as a result of what is in the curriculum and methods used by the teacher to impart the curriculum. The International Technology Education Association asserted that all high school graduates ought to be technologically literate, meaning that they can 'understand the nature of technology, appropriately use technological devices and processes, and participate in society's decisions on technological issues' (1996:1).

There are various features of the nature of technological literacy that makes the design of such tasks a difficult proposition. To resolve this problem, many technology education programs limit the scope of their curriculum to a single content organizer, e.g. "industrial" technology. In the South African national curriculum, policy documents specify that four areas - Systems and Control, Communication, Structures and Processing, should comprise the main content organisers for technology. Policy further requires evidence of learner achievement with regard to the acquisition of knowledge and skills in respect of the application of Safety, Information, Materials and Energy. The content organisers, which also comprise the main knowledge areas represented by the PUT instrument, are described below.

- *Systems and control:* (including mechanical, electrical, hydraulic/pneumatic and service systems). Knowledge and understanding will be applied within an understanding of input, process and output; open and closed systems; concepts of technological systems; components, devices and operations; the way signals flow in and between systems; the multiple and complex nature of interconnections between and within as well as the control of the different types of systems.
- *Communication:* Knowledge and understanding will be applied within an understanding of the use of appropriate technical design and development skills, technical language and conventions for product development to meet given purposes and specifications (e.g. layout, graphics and data presentation).
- *Structures:* (including frame, shell and solid/mass). Knowledge and understanding will be applied within an understanding of complex, made structures, reinforcing within complex made structures, composite materials; internal and external forces; simple calculations and formulae associated with volume, force and other structural theory concepts. Structures should include shelter, transport, storage, containerisation, etc.
- *Processing:* (including food, textiles, and resistant materials like card, wood and plastics). Knowledge and understanding will be applied within an understanding of the activity of processing raw materials into refined materials and into products, with waste as a by-product. Processes will include conversion, preservation, reduction and combination. Processing should occur in the context of bio-technology, manufacturing, agriculture or mining.

(From Senior Phase (Grades 7-9) Policy document, Department of Education, October 1997).

2.5. Measuring technological literacy

Snow (1993) suggested that multiple-choice items and student portfolios represent opposite ends of a continuum of response structure. Messick (1994) implied that a mix of assessment strategies that includes structured exercises and open-ended performance tasks might be useful for achieving breadth of coverage within a domain. The implications of these views are that multiple strategies, rather than a single mode, are more likely to tap the range of competencies included in a domain. For assessment to be considered authentic, however, there are other criteria besides breadth of coverage that must be met. Linn et al. (1991) states it is important to consider meaningfulness. All forms of structured items, particularly multiple-choice, and to a lesser extent semi-structured ones seem to be disconnected form the real world and to be contrary to authentic assessment. It is critical that such items be seen as useful only as part of a wider range of assessment procedures and applicable principally to the knowledge domain of technological literacy. Dyrenfurth (1988) reported on the use of a paper and pencil test of technological literacy that attempted to assess some domain knowledge and some of the attitudes thought to be indicative of technological literacy. However, P. John Williams (1996) asserts that such measures are limited because they ignore the strong element of capability that technological literacy involves.

Technological literacy is constituted by both functional knowledge (what learners get from everyday life) and school knowledge. The main assessment question here is what students know about technology, independent of the taught curriculum. Prime (1992) found this to be true for a sample of secondary school students in Trinidad, whose experiences in the home environment was the largest determinant of their attitudes toward technology. Thus, assessment tasks should allow students to display understandings drawn from both in-school and out-of-school experiences. Furthermore, changes in technological literacy need to be systematically documented through the use of portfolios, documentation, and graphic presentations. These performance assessment formats support both the process and product goals of technology.

The fact that technological literacy is essentially about functional competencies in the real world may be the source of the greatest assessment challenge i.e. to design assessment tasks that incorporate the salient elements of the real world in which technological literacy is actually displayed. Most assessments, even performance assessment, runs the risk of being too formalized and decontextualised to provide evidence about real-world functional competencies, in which case they may reveal little of what a learner is likely to be able to do in the real-life context. Given the iterative nature of the phases of technological activity, it might well be that performance at any phase carried out in isolation would be different from what it would be if done in the context of the whole process. Often people other than the creators determine the success of a technology, e.g. in commercial settings where the consumer often determines success. Functional competence thus implies a sensitivity to the humanness of technology and, more specifically, to consumer issues. If one assesses students' capabilities in evaluating technology out of the context or contact with real clients, a vital aspect of real-world functional capability may not be measured or realized. The balance in such assessment is clearly on the side of the processes rather than on the products, and the activities rather than the outcomes of students' technological work. Even performance-oriented assessment will fall short of its goal unless the design of such assessment strategies is informed by a careful analysis of the elements of real-world functional competency. These approaches produce a high level of student engagement with tasks, and blur the lines between learning activities and evaluation. In such situations, assessment becomes an integral part of the instructional process and exerts its most positive influence on teaching and learning. The use of student portfolios, group as opposed to individual tasks, performance as well as product evaluation, ongoing as opposed to single-event assessment, and open-ended rather than closed tasks are strategies that make learning visible as it progresses and unfolds in its uniqueness for each learner. It seems evident that these approaches to assessment are the ones that will provide the best evidence of technological literacy. Use of a common yardstick by which to measure individual outcomes has been one of the hallmarks of traditional forms of evaluation. This is in essence a validity issue. In a discussion of the nature of performance assessment, Messick (1994) suggested that 'authenticity' and 'directness' which are qualities claimed to be characteristic of performance assessment, are related to the issue of validity. Frederikson and Collins (1989) and Linn, Baker, and Dunbar (1991) proposed that specialized validity criteria need to be invoked for performance assessment. The issue of validity as it relates to the assessment of technological literacy will be addressed later.

Developmental variations in the achievement of technological literacy are expected. A student at age ten may be technologically literate to some extent, but at age fifteen may not be. Technological literacy is not an all-or-nothing learning and should not be described in those terms. Instead it should be defined at a minimum for any given developmental stage. Regardless of the ultimate definition of technology, there is a need to avoid the development of an omnibus instrument to measure it. Instead, the concept would have to reflect variation in grade or developmental level. Measuring the technological literacy of a child at grade 3 level thus has to be different from measuring that of a child in grade 9. Adults would require a different form of the instrument than children. It is often implied in the literature on technological literacy that is possible to attain a maximal level of literacy. Given the context-specific nature of technology, a student may be knowledgeable in one domain, e.g. Systems, but less literate in another domain, e.g. Structures. That unevenness may be due to variations in teaching, to curriculum content, to student interests, or to a host of other reasons. Whatever the case, the unevenness is merely an indication of individual human development. The PUT instrument is differentiated for Foundation and Intermediate/Senior phase learners, thus taking into account the need for this differentation. Dyrenfurth (1991) suggests that the development of technological literacy proceeds along a continuum from 'non-discernible' to 'exceptionally proficient' then students will be situated at varying points along that continuum. Assessment tasks for technological literacy should allow students to function at their most advanced points along the continuum.

How to deal with the content of technological literacy instruments is complicated, but there is a clear need for instrumentation. Several versions of instruments are conceivable, some assuming a process approach to the subject, and others taking a content approach. In a process approach, technological literacy might focus on items that test critical thinking or problem solving. In a content approach, specific content knowledge would have to be tested, reflecting the main areas of the field.

2.6. Attitudes towards technology

It could be assumed that if students have a tendency to act positively toward a subject, for example, technology, then students will have more of an interest in that subject (Krathwohl et al., 1964). Thus, if one of the educational goals of technology education is technological literacy, then students exhibiting a positive attitude toward technology would be more likely to attain technological literacy through technology education

(Bame, et al., 1993). Raat and de Vries (1985) investigated the attitudes of middle school students toward technology in order to develop course materials that could apply technological concepts and practices in a physics curriculum. The project titled Pupils' Attitudes Toward Technology (PATT) sought to determine students' attitudes toward technology and their understanding of technological concepts. Raat and de Vries concluded that: (a) students had only a vague concept of technology, (b) the relationship of technology to physics was very obscure to students, particularly among girls, and (c) girls are less interested in technology and see it as less important. It is suggested that students who have a positive experience in technology education will develop a positive attitude toward technology and the pursuit of technological careers, and would therefore be more interested in studying about technology. As a result, students should become more technologically literate. This premise is grounded in research from the affective domain that indicates that students who exhibit a positive attitude toward a subject are more likely to actively engage in learning during and after instruction (Popham, 1994).

Given the nature of technology. i.e. that it is co-operative; relies on the use of different knowledge bases, processes and skills to create and/or critically evaluate a design, product, system and environment; relies on teaching approaches that are flexible, open and collaborative to accommodate all student interests, aspirations and learning styles; students need to be able to deal critically with ethical and social issues and the impacts of technology and the potential benefits associated with the application of technology. Thus assessment must address these varieties of ways of realising the processes and outcomes of technological activity. Technological outcomes include artefacts, systems and environments. To achieve in technology education, students may employ many different approaches and use a variety of appropriate knowledge and skills in working towards these outcomes. Assessment procedures need to accommodate the diversity that will be present in technological activity, and must reflect the processes undertaken. The series of appropriate technological literacy assessment approaches presented here embody many of the principles of illuminative assessment. Multiple strategies, which employ concrete activities that are relevant to the lives of students and are grounded in the real world, are advocated here. Increasingly, the term assessment is being used to signify the change from an almost singular reliance on tests that gave quantifiable results to methods of evaluation that recognize the complexity of human functioning and that more closely reflect the real-world context of human performance. Indeed terms such as *authentic* and *illuminative* (Hodson & Reid, 1988), and *expressive* (Eisner, 1993) are being used to describe assessment procedures that elicit a display of student learning in its uniqueness and complexity.

2.7. Assessing technological content

In implementing technology in elementary education, curriculum developers have found that even teachers who have widely used this unit in science education have problems in interpreting the very idea of a switch. It is difficult to justify knowledge about electric circuits for literacy purposes. If one weighs the time required for successful instruction, as suggested by research, against what can be gained, then electric circuits do not have much to offer to literacy (AAAS, 1999a). Few people will need this knowledge for their lives, since most of the electrical work (e.g., wiring a house) is done by certified technicians, and the use of electric artefacts (e.g., a computer) does not demand this knowledge anyway. However, behind the notion of an electric switch are important technological ideas about control systems that are fundamental for literacy. It is important to know about *control systems* because they influence the behaviour of people and things. In its recommendations about control systems, *Benchmarks* suggested that:

> *An idea to be developed in the middle grades is that complex systems require control mechanisms. The common thermostat for controlling room temperature is known to most students and can serve as a model for all control mechanisms (AAAS, 1993: 50).*

However, the idea of complex systems is extended beyond physical systems: "Students should explore how controls work in various kinds of systems, machines, athletic contests, politics, the human body, learning, etc." (ibid.: 50). In short, an electric switch can be seen as one context for learning more important technological ideas, particularly ideas about *control systems*. Similarly, learning about the specific properties of specific metals is not very important for literacy purposes since only certain members of society need this specialized knowledge (technicians who have to deal with metals, some kinds of engineers, some kind of artists, etc.). However, there are general ideas about materials that everyone should know (AAAS, 1989; Amato, 1998). For example, a K-2 benchmark states that:

> *Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways (such as stronger or cheaper) may be worse in other ways (heavier or harder to cut). (AAAS, 1993: 188).*

Before students can learn that some *materials* are better than others, it is important to work with them in distinguishing between objects and the properties of the *materials* of which they are made. This is the connection presented before the learning goal that states, "Some kinds of materials are better than others ..." (K-2 level).

Children (and teachers) have problems distinguishing the properties of the objects (e.g., this sheet of paper has a rectangular shape) from the proprieties of the material that made the objects (e.g., the flexibility of the paper). In fact, research has shown that:

> *The tasks of classifying objects according to what they are made of and of comparing properties of materials can be challenging for early elementary-school children. In addition, elementary children may have limited knowledge or hold misconceptions about the origins and transformations of materials (AAAS, 1993: 349)*

Since the work of Piaget, science educators have explored how children describe materials in terms of their physical properties. Because science education has different goals than technology education, research in science education has focused on how children describe physical properties. From the science education perspective, descriptions of physical properties of objects are the basis for understanding later important idea s such as conservation of matter, states of matter, and chemical reactions. What are the important technological ideas we want students to learn with their understanding that some materials are better than others? How relevant is this science education research for technology education?

A crirical question is what do students need to know in order to understand ideas related to materials, particularly that some materials are better than others (K-2 level)? Research in science education on how children learn about materials and their properties may serve as a starting point. However, this research has not explored "functional" properties of materials (i.e., properties of materials based on their use such as those suggested by Benchmarks: strength, stiffness, hardness, and flexibility). There is almost no research on how students learn these ideas. In the context of the map, ideas about materials in grades K-2 are the basis for learning about design at higher levels. Students should understand that design requires taking constraints into account, some of which have to do with the properties of the material to be used (AAAS, 1993).

Eisner (1993) suggests a number of criteria for assessment practices in education including notions of curricular relevance and tasks needing to reflect the tasks students will encounter in the world out side schools, both of which are particularly relevant for technology. As well, in selecting situations and strategies for assessment, teachers must be sensitive to the needs of their students and their different learning and communication styles. Eisner believes that assessment tasks should permit the students to select a form of representation he or she chooses, to display what has been learned. Recognition of this individuality means that students need not encounter the same items, and that individual interpretation and creativity are valued.

Students will be involved in group and collaborative technology activities, and so strategies for the assessment of group and collaborative work will need careful consideration. Technology also offers opportunities for ongoing self and peer assessment strategies to be. Assessment strategies need to be developed which emphasize the importance of managerial and collaborative activity rather than limited only to sole performance. Assessment tasks should make possible a variety of solutions to a problem, and more than one acceptable answer to a question. The multi-dimensional nature of technology raises a number of issues that need addressing in the teaching-learning-assessment context.

The teaching, learning and assessing of a technology activity must recognise both the procedural and conceptual aspects of technology. Emphasis on any one in isolation will distort student learning in technology. Research (McorMick, Murphy, Hennessy, 1994) indicates that there are a number of problems associated with conceptual knowledge in a curriculum with a strong emphasis on procedural knowledge. Technology assessment must incorporate practical capability as an integral component of technological activity. Relying on one form of assessment may not offer an acceptable way of assessing technology. Ways of assessing the procedural AND conceptual aspects need to be understood. Technological areas, contexts and the way related variables are identified and operationalised, affect the complexity of the task. It is important that students experience and are assessed in a variety of contexts and areas. Kimbell (1994) argues for student assessment to be initially assessed holistically, followed by the identification of constituent strengths and weaknesses.

In his review of the implementation of technology education in a few countries (Australia, Canada, the United Kingdom, including Scotland, Kenya and the United States), Vijay Reddy (1997) identified some of the key factors affecting the successful implementation of technology education. Recurring challenges in these countries include the inexperience and lack of confidence of technology teachers, the lack of district/regional and school-level support, staff and material shortages and the lack of a clear vision for technology within the curriculum. The country-specific differences are summarised below.

In Australia, different perceptions amongst teachers of the nature of technology led to the adoption of different approaches to curriculum implementation. Implementation plans were further affected by the location of the school, variations in the size and nature of the student population and the community context. In addition, major factors constraining the attainment of technology education outcomes included the high degree of dependency of the project coordinator, high staff turnover, the lack of articulation between new staff and those leaving the school and the lack of consensus on what the focus of technology should be.

In Canada, limited financial support for implementation, facility planning, teacher training and research inhibited the implementation of technology education. There was also a lack of interest from the community of the local districts because of a lack of active promotion of the programme by educators. In addition, teacher training and re-training were pivotal – in Canada, teacher re-training tended to have a relatively low priority, which significantly impacted on the diffusion, adoption and implementation of technology education. This study underlined the centrality of teachers and the need for educator INSET training.

Sam Bahaj in his assessment of factors that determine the success of technology education implementation in Africa, names adequate human and material resources, as well as the existence of programmes to enhance the participation of girls and women in science, technology and mathematics. He recommends that greater attention be paid to the training of teachers and teacher-trainers.

In the UK, Stables (1992) states that very few primary teachers have received formal training in the teaching of technology. A further concern has been the lack of a smooth progression between the primary and secondary phases. She identifies some key factors in facilitating technology education implementation:

- an enthusiast for technology in the school, to support the efforts of teachers
- formal arrangements at the school with regard to provisioning, which encompasses storage, maintenance and access

- support from the district / region for inexperienced science and technology teachers.

These factors contribute significantly to variations in the nature of technology education implementation within countries. It is expected that such variations will in turn differentially affect learning outcomes such as the attainment of technological literacy. Thus, learner outcomes should be described bearing in mind the particular technology (resourcing and physical) implementation context.

2.8. Conclusion

This review of literature frames the discussion on both the findings and the substantive aspects of technological literacy. In it, the nature of technology and of technological literacy have been presented as a preface to the discussion on the potential challenges to validly assessing technological literacy, and in particular technological knowledge and understanding. The chapters that follow (Chapters 3-7) present the findings on a test of learner knowledge and understanding, the PUT, in technology for the three grade levels.

CHAPTER 3
METHODOLOGY

3.1. Introduction

The previous chapters have presented the structure and purpose of this thesis (Chapter 1) and the local and international literature on technological literacy, (Chapter 2). The purpose of this chapter is to report on the methodology for this study in order to inform interpretation of the findings in Chapters 4-7. As such, it begins by describing the sample, the PUT instrument, the data collection and data analysis procedure. Importantly, it also discusses aspects of the reliability and validity of the PUT by reviewing the relevant theoretical literature.

3.2. Methodology

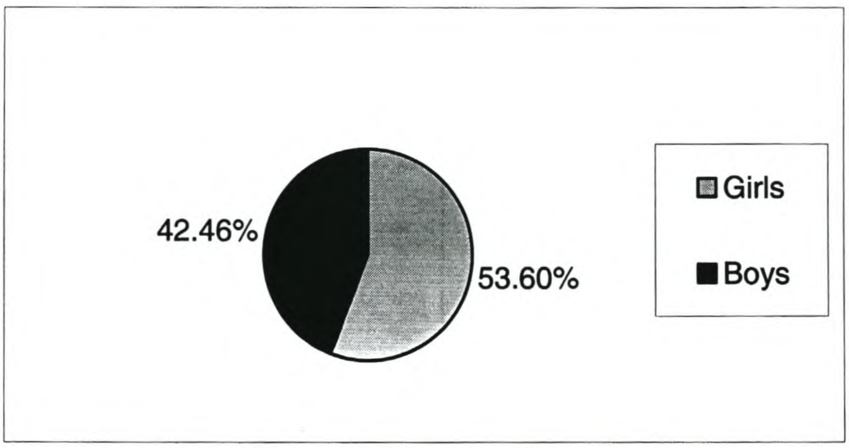
3.2.1. Population and Sample

The research sample of 12 schools was derived from a larger sample of pilot schools that had participated in the Technology 2005 Implementation Evaluation in 1998, one year before the present study. Although the original sample focused on schools in three provinces - Kwa-Zulu Natal, Gauteng and the Western Cape, only the Western Cape pilot schools were selected to be part of the final sample for this study. The present sample consists of intact classes of learners in 3 grades, each representing the exit level for each phase within the GET band. Thus, learners from Grade 3, Grade 6 and Grade 9 classes were selected, representing Foundation, Intermediate and Senior Phase learners respectively. The total number of learners who participated in this study is 459.

3.2.1.1. Gender distribution

The sample consists of a slightly higher percentage of girls (53.6 %) than boys (46.4 %). This difference is however not statistically significant. Figure 3.1. represents the distribution of boys to girls.

Figure 3.1.: Gender distribution for entire sample



A comparison of the gender distribution by grade / phase level reveals that whilst at both Foundation and Intermediate phase girls comprise the majority, at the Senior phase there is a higher percentage of boys. No statistically significant differences are observed in the number of boys versus girls within the respective phases. Table 1 below reflects the gender distribution by phase.

Table 3.1.: Gender distribution by phase

Phase	Gender	N = 459	Percent
Foundation Phase	Boys	n = 58	46.4%
	Girls	n = 67	53.6%
	Total	*n = 125*	*100%*
Intermediate Phase	Boys	n =71	39.7%
	Girls	n = 108	60.3%
	Total	*n = 179*	*100%*
Senior Phase	Boys	n = 86	55.5%
	Girls	n = 69	44.5%
	Total	*n = 155*	*100%*

3.2.1.2. Distribution by geographic location

The sample includes schools from rural and urban areas. Figure 3.2. indicates the distribution per phase by geographic location. As can be seen from the graph, most schools in the sample are urban schools. Both the rural and urban schools may be further differentiated according to their socio-economic status. Table 3.2. shows the breakdown per phase by geographic location and socio-economic status.

Table 3.2.: Distribution per phase by geographic location and socio-economic status

Phase	Geographic location	School code
Foundation Phase	Rural Urban Peri-urban	F1 F2 F3
Intermediate Phase	Urban (middle class) Urban (poor white) Urban (township) Rural	I1 I2 I3 I4
Senior Phase	Urban (middle class) Urban (township) Rural (middle class)	S1 S2, S3, S4 S5

3.3. Instrumentation

3.3.1. The PUT

The performance in technology of a sample of learners has been assessed by means of the Pupil's Understanding of Technology (PUT) test. A copy of the PUT is attached (See Appendix A). The PUT is differentiated into two versions – one for Foundation Phase and another for Intermediate / Senior Phase respectively. The PUT format is designed to reflect differences in achievement in technology based on both individual learner factors as well as school factors. Thus, the first part (Part 1) of the PUT contains information about the learner such as name, age, sex, grade level and educator name. Although both versions of the PUT consist of these two parts, the second part is slightly differentiated for each phase: Part 2 is comprised of test items divided into 4 sections for Foundation phase and 7 sections for the Intermediate (Grade 6s) and Senior Phases (Grade 9s). Part 2 samples both relevant technological content and skills, as described in the curriculum objectives for the Technology learning area. Technology practitioners, including members of the National Technology Task Team, Technology 2005 evaluation team and private consultants with expertise in technology education, carried out the construction of the PUT. The items were developed in accordance with Bloom's (1971) taxonomy for the cognitive domain. Thus, the PUT includes items on both the lower end of the cognitive continuum (e.g. 'identification' and 'recall') and items on the upper end, (e.g. 'comprehension', 'knowledge' and 'understanding').

The Intermediate/Senior Phase version of the PUT contains a higher number of items at the higher levels of the cognitive continuum than the Foundation Phase version of the PUT. This is consistent with theory on technology learning outcomes, according to which technological knowledge is a subset of general achievement. Thus, as in the measurement of general achievement, different levels of item difficulty are required at different points on the developmental continuum.

3.4. Data collection

The PUT data was collected from mid-August to September 1999. After formal consultation with the school principal (via a letter requesting approval), and telephonic consultation with the individual educator responsible for the Technology class, the PUT was administered to learners in a test session of approximately one hour long. When initially approached, principals and educators expressed some reservations about 'testing' their learners, because:

> *We have not yet started implementing OBE. (Principal, I1)*

I attended the training, but we haven't done much as far is technology is concerned. (Principal S2)

They were reassured that these factors would be taken into account in contextualising the achievement of their school's learners on the PUT. Interestingly, in many of the classes in the sample, especially at the higher grade levels, learners intuitively organised themselves into groups, or initiated discussion of the PUT items. Thus it appears that the mode of delivery of Technology within an OBE framework (e.g. co-operative group work / team work) had taken root to some extent in many classes, despite the reservations expressed above. Thus, the PUT assessment format, which prescribes individual, rather than group work, appears to be antithetical to the recommended framework for teaching and learning in Technology.

In Q1.5, in which learners were required to draw three possible solutions to the design problem, learners expressed some frustration. Some learners asked if they could simply describe the solution narratively, rather than have to draw the solution. Others had a strong preference for one of the three possible options, and so could not fully describe the other two options, as these were (at least in their minds) weaker options. Thus, a combination of limited available time for drawing three options, and the fact that learners spent most of their time perfecting the model they saw as the best option, resulted in the item being poorly answered. In scoring, the item was excluded altogether for Foundation phase learners, but retained for Intermediate and Senior Phase learners. For the latter groups, only the feasibility of the solution was evaluated. No other criteria (e.g. creativity of the solution, sophistication of the drawing, etc.) were applied.

The PUT for both Foundation and Intermediate/Senior Phase learners was translated into the three primary languages of communication and of instruction in the Western

Cape region, viz. Afrikaans, English and Xhosa. However, particularly in the higher grades and where Xhosa was the mother tongue of learners, technology lessons are conducted in English. Both educators and learners in these classes expressed a preference for the test to be administered in English. Test instructions were standardised for all classes in the sample. For Foundation phase, instructions were explained item by item, and repeated in detail, as learners generally had difficulty reading and comprehending written instructions (evidently because of their inability to read at this level rather than as a reflection of item difficulty.) Even where instruments were administered in English, learners were permitted to respond in the language of their choice. Most Xhosa learners responded in Xhosa. A mother tongue Xhosa speaker, a masters student, before analysis, translated these responses back into English.

The test administration time for the Foundation phase was slightly longer than for the Intermediate and Senior phases. Due to the fact that no pre-testing of the PUT had been conducted, as was expected, learners encountered various problems with interpreting test items. It appeared that most of the learners had little knowledge and experience of the different item response formats in the Foundation Phase (i.e. matching items vs multiple choice selection from a grid).

Some Foundation phase learners had difficulty filling in their names and ages.

There are two key concepts that must be considered in the development and administration of any evaluation instrument. These concepts are reliability and validity. In the section, which follows, each of these concepts will be examined in turn, with particular reference to the PUT instrument.

3.5. Reliability and validity

3.5.1. Reliability

3.5.1.1. Definition of reliability

The reliability of a test has been described as 'the consistency with which it yields the same results'. Thus, when the same takes the same test individual on two occasions, or when two forms of a test are taken by the same sample of individuals, the individuals will usually obtain different scores. The difference is in part due to errors in measurement. As such, as errors become larger, the reliability of the test becomes lower. Furthermore, three aspects of reliability are identified – the equivalence aspect, the stability aspect and the homogeneity aspect. The degree to which reliability has been achieved in this study with regard to each of these aspects, will be examined below.

3.5.1.2. Aspects of reliability

The equivalence aspect of reliability refers to the amount of agreement between instruments administered nearly at the same time. As no external test was administered to establish reliability resulting from equivalence, this aspect does not apply to this test. Inter-rater reliability test this refers to the amount of agreement in scores per item between two raters. Although the scoring procedure and answer sheet was validated by knowledgeable 'experts' in the field of technology, and reported to be a valid representation of the technological skills and content the PUT sought to sample, this was conducted before the actual scoring took place. Thus, the amount of agreement in scores (the inter-rater reliability) was not statistically determined for the PUT. However, all test items are scored the same for all learners with absolutely no variance.

The stability aspect of reliability: This refers to test-retest reliability and parallel or alternate forms reliability, which is not relevant here, as there was no repeat measure of the PUT, nor was there an alternate form of the test administered. There are also number of factors that can contribute to a reduction in reliability:

3.5.1.3. Potential threats to reliability

Potential threats to reliability include a lack of objectivity, inappropriate test length, lack of clearly written test items, the possibility of guessing, lack of quality, clarity and consistency of test directions and the effects of repetitive testing. In designing and administering the PUT, several procedures and standards have been introduced to help reduce the amount of unpredictable error in the test. These include:

Ensuring objectivity

By minimising the number of constructed response items the item response format limits the degree of variability due to variations in learner responses, and the concomitant need to assess items on a more individualised, subjective basis. Thus, scoring of PUT responses, being objective, increases the reliability of the scoring procedure.

Ensuring appropriate test length

In attempting to design a developmentally appropriate instrument to assess learner understanding(s) of Technology, the PUT is differentiated for the Foundation phase (Grade 3) and Intermediate-Senior phases (Grade 6 and Grade 9) respectively. Not only are the cognitive demands for the Inter-Senior Phase instrument higher, but also the length of this instrument assumes that theory on attention span is accurate in asserting that effective time on task is positively correlated with developmental level.

Controlling for the guess factor

Not including any true-false questions, and utilising an adequate number of distracters for multiple-choice questions and an adequate number of test items for matching items have also reduced the guess factor. Another major contributing factor to reducing the 'guess factor' is the quality of the distracters for multiple-choice items.

Effects of repetitive testing

Mainly due to lack of prior testing of items, and lack of a thorough process of item revision, some of the following threats could not be adequately controlled for:

Lack of thorough pre-testing of the PUT

Whilst curriculum and content experts have evaluated the PUT, its psychometric properties have not been evaluated. In addition, due to time restrictions in carrying out the data collection, the PUT was not subjected to pilot testing or item revision. Furthermore, the translation of the PUT into three languages further underlines the need for pre-testing so as to eliminate potential differences due to language.

The effect of poorly written test items

As stated above, the majority of the items require non-constructed responses. As such, a degree of reliability is already established. In some cases, however, the item wording has clearly been a source of variability between expected and achieved scores.

Lack of quality, clarity and consistency of test directions

Although the test instructions for facilitators were specified to be standard across all test sessions, various languages were used at all three phase levels to address learners on how to complete the test. Although, an attempt was made to limit further explanation of test directions to what was stated in the test booklet, there is a possibility that in using different languages, some of the clues to correct responses could have been inadvertently introduced.

3.5.2. Validity

Validity has been defined as 'the degree to which a test measures what it claims to measure'. In other words, a valid test accomplishes what it was designed to accomplish. However, recent theorists have noted that this definition does not account for the fact that there is more than one kind of test validity. The field of evaluation and measurement generally recognises four kinds of measurable validity – content, concurrent, predictive and construct. A fifth kind, face validity, does not provide measurable evidence of validity but can provide valuable supplemental subjective information. Each kind of validity has varying degrees of importance depending on the purpose of the testing. The following section will briefly describe each component of validity, and its relevance to the purpose of this study.

3.5.2.1. A modern concept of validity

Messick, S. (1989, 1996A, 1996b) argues that the traditional concept of validity is fragmented and incomplete, especially because it fails to take into account both evidence of the value implications of score meaning as a basis for action, and the social consequences of score use. His modern approach views validity as a unified concept, which places a heavier emphasis on how a test is used. Six distinguishable aspects of validity are highlighted as a means of addressing central issues implicit in the notion of validity as a unified concept. In effect, these six aspects conjointly function as general validity criteria for all educational / psychological measurement. These six aspects must be viewed as interdependent and complimentary forms of validity evidence and should not be viewed as separate and substitutable validity types. Messick distinguishes:

Content validity: determining the knowledge, skills, and other attributes to be revealed by the assessment tasks. Content standards themselves should be relevant and representative of the construct domain. Increasing achievement levels or performance standards should reflect increases in complexity of the construct under scrutiny and not increasing sources of construct-irrelevant difficulty.

Substantive validity: the substantive aspect of validity emphasizes the verification of the domain processes to be revealed in assessment tasks. When determining the substantiveness of a test, one should consider two points. First, the assessment tasks must have the ability to provide an appropriate sampling of *domain processes* in addition to traditional coverage of *domain content*. Also, the engagement of these sampled in the assessment tasks must be confirmed by the accumulation of empirical evidence.

Structure score models: The manner in which the execution of tasks are assessed and scored should be based on how the implicit processes of the respondents' actions combine dynamically to produce effects. Thus the internal structure of the assessment should be consistent with what is known about the internal structure of the concept domain.

Generalisability: Assessment should provide representative coverage of the content *and* processes of the construct domain. This allows score interpretations to be broadly generalisable within the specified construct. Evidence of such generalisability depends on the tasks' degree of correlation with other tasks that also represent the construct or aspects of it.

External Factors*:* The external aspects of validity refer to the extent that the assessment scores' relationship with other measures and non-assessment behaviors reflect the expected high, low and interactive relations implicit in the specified construct. Thus, the score interpretation is substantiated externally by appraising the degree to which empirical relations are consistent with that meaning. Consequential aspects of validity: the challenge in test validation, then, is to link these inferences to convergent evidence which support them as well as to discriminant evidence that discount plausible rival inferences.

3.5.2.2. PUT characteristics

3.5.2.3. Limitations of a paper-and-pencil test

Some of the limitations of the PUT include the lack of representative coverage of the content *and* processes of the construct domain and inconsistent reflection (in assessment and scoring) with the internal concept of the domain. McGinn and Roth (1998) commenting on the universally acknowledged inadequacy of paper-and-pencil tests, contend that

> *paper-and-pencil tests systematically bias the assessment of student competence in that only those abilities that are amenable to paper-and-pencil measures - recalling facts and solving short, well-defined problems - have counted in measures of student competence (p 813).*

Drawing on findings from their own research of Grade 6/7 mixed-ability students' performance on a test assessing their understanding of levers, they concluded that 'better instruments are not enough' (1998: 813). As anticipated, the study revealed differences in performance of students across performance/assessment formats (paper-and-pencil tests, interviews, and physical activity) and contexts/social configuration (group/individual.). They concluded that competence is heterogeneous, not unitary. As such, if assessment is to be 'authentic' it should reflect this heterogeneity. They contend that one score is not adequate in assessing a range of competencies. They concur with other theorists in the conviction that these scores can be used in concert with other measures, in particular (in technology education), the process of designing may be determined through an evaluation of the portfolios learners create. Even then McGinn and Roth contend that 'most of the sophisticated processes by means of which they had arrived at their reports were not recoverable from the written reports.' (p 830). They propose that in addition to the methods used, learners should be observed *in situ* (through film) to enhance the evaluator perspectives of the learner performances.

3.5.2.4. Limitations of measuring only one dimension of technological literacy

Limitation: construct under-specification.

Local and international literature on technology education identifies the primary goal of a technology curriculum to be the development of technological literacy. Various definitions of technological literacy emphasise its multi-dimensional nature. Dyrenfurth and Kozak (1991), for example, speak of the dimensions of the following dimensions: the ability to use technology (the practical dimension), the ability to understand the issues raised by or use of technology (the civic dimension), and the appreciation for the significance of technology (the cultural dimension). Jones (1996) stress the inter-relatedness of these components, and the necessity of assessing these *holistically* rather than as discrete competencies. Stables (1992) asserts that there is a growing consensus of the imperative for developing *generic* competencies, with broader-based utility as opposed to more specialised skills. This is part of the rationale for developing '*holistic technological capability'* (p 4). Hill (1996) characterises this '*integrated* study of technological processes, knowledge and context' as 'one of the aspects that should distinguish technology education from other program areas that address technological content' (1997:2). Furthermore, HEDCOM (1995) has classified the goals of the technology curriculum according to Kratwohl et al.'s (1971) taxonomy of educational objectives, whereby cognitive, affective and psychomotor dimensions are identified. The PUT instrument, however, only examines one of these critical dimensions.

Ortega and Ortega distinguish between two types of technology activities: 'technology learning experiences', and 'technology design problems' (1995: 13). The technology learning experiences are meant to foster an awareness of the types of technology found in the environment, and enable learners to develop an understanding of technology. Such activities may range from reading a story which demonstrates the use of a particular technology for the context in question, to field trips to a supermarket where learners observe different forms of packaging and how technology is applied. On the other hand, technology design problems encourage students to explore various materials through hands-on experiences and learn construction and process skills as they solve problems. The structured context of exploration created during technology problem solving, leads to the acquisition of certain skills - creativity, critical thinking and problem solving and is called process skills. The technology design process thus places equal emphasis on the attainment of outcomes, as it does on the *process* by which these outcomes are accomplished. The category of items on the PUT, which are intended to tap knowledge of this process, however, due to limited administration time, does not permit learners to explore multiple design options. Indeed one correct response is permitted. Thus the PUT as an assessment instrument lacks sufficient correspondence with the goals of technology instruction.

To summarise, the greatest threats to validity are:

- the lack of systematic data on various aspects of technology curriculum delivery which could impact on technology curriculum outcomes;
- the lack of a reliable measure of extra-curricular access to appropriate technological environments;
- the lack of 'authenticity' of the assessment, i.e. lack of correspondence between the mode of delivery of technology (practical, hands-on, group-based) and the PUT assessment format (written, paper-and-pencil, individualised)

3.5.2.1. Validity threats arising from the design of the study

3.5.2.1.1. The weakness of geographic location as an indicator of extra-curricular access to appropriate technological environments

Various evaluations of the effects of curriculum exposure examine the effect of exposure to extra-curricular sources of knowledge such as through peers, hobbies, parental influences, etc. Thus it was recognised that there is a need for the consideration of such factors as potential correlates in evaluating the effect of the technology curriculum on learner knowledge / understanding of Technology. However, due to the absence of relevant information on individual learner backgrounds, the geographic location of the school was used as proxy for a measure of individual learners' extra-curricular access / exposure to technology. However, there are various limitations in the classification of schools according to their geographic locations. Firstly, patterns of rural-urban migration have resulted in a diverse learner population. In the Western Cape, for example, the increasing proportion of rural migrants to the city has resulted in the proliferation of satellite settlements surrounding the major urban centres. Most of the African townships draw learners from these settlements. Thus, even though the peri-urban schools are comprised of learners from these settlements, their rural backgrounds should be considered in the determination of their access to appropriate technological environments. The inadequacy of geographic location as a measure of access to technological environments also extends to a town like Paarl, which, although rural in most respects, is connected to the cities by infra-structural networks comprised of transport, electricity and telecommunication networks, whose function is to facilitate social, economic and environmental flows and linkages. Thus, learners drawn from the Paarl area are in any event exposed to this. In addition, as a boarding school, there is probably considerable variability in learner backgrounds, which, in reference to the relevant variable renders the classification of such learners over-simplistic.

3.5.2.5.2. Absence of information on the schools' capacity to deliver Technology education

The successful delivery of Technology education assumes the existence of basic minimal infra-structural arrangements such as a storage room for technology resources, and sufficient workspace to organise hands-on, manipulative activities. The existence of these conditions is expected to differ across schools, not least because there has been no precedent for Technology in the previous curriculum *(*Nated Report 550*)*. In addition, Eisner (1985) asserts that what learners learn is as much determined by the manner in which the curriculum is delivered, as it is of the content of that curriculum. Theorist concerned with the contingency of performance on instruction, point to structural inequalities, which may disadvantage schools and their students. Kimbell et al. (1991) assert that 'the extent to which pupils are able to get on by themselves is closely related to task structure and teaching style Gustafson et al (1998). Herman (1993) asserts that the issue of inequality in evaluations is compounded by the fact that economically disadvantaged students are less likely to have access to the kind of curriculum that would prepare students to do well on performance assessments. These, he asserts, are the students that are most likely to have been subjected to a drill-and-practice, basic skills curriculum. In particular, teachers appropriately trained in new methods of teaching and with the relevant subject matter background, and instructional materials are less likely to service such schools. In the context of children's technological problem-solving, McCormick et al. (1992) and Kimbell et al. (1991), emphasise the pivotal role played by teachers in setting the context for childrens' technological problem-solving. Davidson et al. note however, how teachers' lack of pedagogical and subject matter knowledge, particularly amongst teachers at this level can lead to '... a ritualistic approach to technological problem-solving' (1998: 152). The ramification is that opportunities for students to learn higher level cognitive skills is stunted by old pedagogic habits. Furthermore, the successful delivery of Technology education requires the existence of certain minimum infra-structural arrangements. In addition, particularly in a new/piloted learning area like Technology, there is a need for constant, active support from sources on-site as well as off-site. With these considerations in mind, it is considered imperative to differentiate between schools according to their capacity to deliver the technology curriculum. Thus greater consideration could have been given to two classes of factors: classroom infrastructure and support for technology. The issues which could have been examined more closely under these categories of variables include:

<u>Classroom physical infrastructure:</u> Does the class have a dedicated technology storage/utility room, are electricity and water outlets present and working in the

classroom, is there sufficient space for Technology classroom activities, are there sufficient LSMs for Technology visible in the classroom, etc.?

Support for Technology: Do colleagues, management and districts support the delivery in a substantive manner?

Educator training/subject knowledge: Have educators received adequate training in the delivery of a Technology curriculum?

3.5.2.5.3. Lack of information on the 'perceived' curriculum

As designated Technology pilot schools, all schools sampled have been mandated to introduce Technology as part of their curriculum. In this regard, Goodlad's (1978) distinction of five types of curricula is instructive: *ideological, formal, perceived, operational* and *experiential.* For the purposes of this study, *formal* and *perceived* curricula types are significant. Formal curricula are curricula in the form of documents, which have the status of being officially approved, and perceived curricula are concerned with the perceptions of educators with reference to curricula. The disjuncture between these types results in variations in the *enacted* curriculum. Since the study did not include a record of the form and content of the perceived curriculum, test construction is based primarily on the aims of the formal curriculum as stated in the Draft Curriculum Framework for Technology. Thus, it was recognised that differences in the enacted curriculum may account for some of the variation in performance on the PUT.

3.5.2.5.4. Lack of information on the nature of technology curriculum organisation

Possessing relevant information on the nature of the technology curriculum is also a key factor in determining technology curriculum outcomes. Lack of information on the manner in which the technology curriculum is organised within schools is thus a key limitation in assessing technology outcomes. It is possible that in some schools, due to staff restructuring, there are severe constraints imposed on the available teaching resources. In such cases, technology may be offered as part of the allocated time for another subject, often resulting in subject integration. Recent literature on integration suggests that the outcomes for integrated technology instruction varies from the learning outcomes for technology as a separate subject. Thus, there is a need to ascertain precisely what model the school has adopted for curriculum delivery, if the effects of exposure to the technology curriculum are to be validly assessed.

3.5.2.5.5. Lack of information on the model of technology introduced by the school

The Technology 2005 Evaluation report details differences in the agencies and models tasked with the preparation of Technology educators for implementation. These differences are likely to translate into differences in emphasis in delivery of the technology curriculum. Thus, there is a need to obtain such information so as to account for differences in emphasis amongst educators adopting craft-based vs science-based approaches, for example.

3.6. Data analysis

All data was captured using MSACCESS. Data was then exported to MSEXCEL, where each item was individually scored. Data was then analysed using SPSS for MS WINDOWS. The responses of 459 learners made up the sample for analysis. The data analysis procedure is described in detail for each question on the PUT.

3.7. Conclusion

This chapter has described the overall design of the study, the sample characteristics, and importantly, some of the limitations of the PUT as a valid instrument through which to assess learner knowledge and understanding of Technology. To reiterate, the PUT is high in content validity, but not as high in construct representation. Thus, there is a need for the use of additional measures of the construct to supplement the PUT assessment, in order to obtain a more valid and reliable representation of what learners would have learned through exposure to the technology curriculum.

CHAPTER 4
RESULTS FOR FOUNDATION PHASE LEARNERS

4.1. Introduction

The primary objective of this study was to examine the effect of exposure to the Technology curriculum on learner knowledge and understanding of Technology. A secondary objective was to examine the effect of gender and geographic location on learner performance on a test of technological knowledge/understanding, the PUT. This chapter reports the results for the Foundation Phase. The PUT for Foundation Phase is divided into 4 categories of items, all measuring some aspect of the learners' knowledge/understanding of Technology. These categories relate to Systems and Control (Q1), Processing (Q2), Materials and Equipment (Q3), and Materials and Components (Q4) respectively. For each category the learner performance by individual item will be presented, followed by learner performance on the total set of items. A breakdown of the total score by gender and geographic location is also given.

4.2. Performance on 'Systems and control' [Systems] – (q1)

4.2.1. Performance on 'Systems' (Q1) by Individual Item

The first category of items on 'Systems' (Q1) was prefaced by the following statement:

> *In a far off land where there are many poor people, there lives a little boy called Jonas. He is a kind and sweet boy and everyone in the village likes him. The problem is, Jonas cannot walk. These go-karts were built by his friends to help him get around. Look carefully at the pictures and answer the following questions.*

Table 4.1 summarises the performance of the Foundation Phase learners on the five items that comprise the 'Systems' component.

Table 4.1: Summary of Responses to 'Systems' (Q1) Items

Item	N	Percent	Valid percent
Q1.1: In what ways are A and B the same?	*Missing = 4*	*Missing = 3.2*	
Wrong	7	5.6	5.7
1 Correct	69	54.8	56.6
2 Correct	34	27.0	27.9
3 Correct	12	9.5	9.8
Total	122	96.8	100
Q1.2: In what ways are A and C the same?	*Missing = 15*	*Missing = 11.9*	
Wrong	25	19.8	22.5
1 Correct	80	63.5	72.1
2 Correct	5	4.0	4.5
3 Correct	1	0.8	0.9
Total	111	88.1	100
Q1.3a: Is one of the go-karts more easily steered than the others? If so, which one? (Circle A, B or C)	*Missing = 4*	*Missing = 3.2*	
Wrong	69	54.8	56.6
Correct	53	42.1	43.4
Total	122	96.8	100
Q1.3b: Why?	*Missing = 4*	*Missing = 7.5*	
Wrong	29	54.7	59.2
Correct	20	37.7	40.8
Total	49	92.5	100
Q1.4: Which one is the least stable and therefore more likely to turn over?	*Missing = 8*	*Missing = 6.3*	
Wrong	69	54.8	58.5
Correct	49	38.9	41.5
Total	118	93.7	100
Q1.5: Choose the go-kart that you think is the best overall design, and circle it in the pictures above.	*Missing = 1*	*Missing = 0.8*	
Wrong	71	56.3	56.8
Correct	54	42.9	43.2
Total	125	99.2	100

Note: The values in the 'Percent' column are expressed out of 126 (with the exception of Q1.3b, which is based on the number of learners who answered Q1.3a correctly, namely 53). The values in the 'Valid percent' column were calculated by using the valid totals for each item, e.g. 122 for Q1.1.

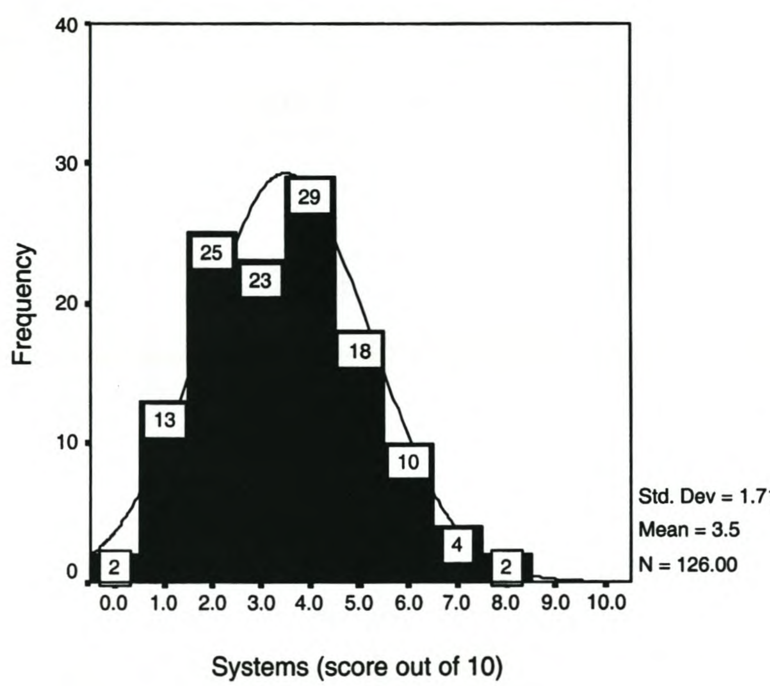
The first two items in Table 4.1 (Q1.1 and Q1.2) merely required learners to *compare* (the three karts) and *identify* (relevant parts), and are relatively low-order items. However, less than 10% of learners were able to correctly identify all three similarities in Q1.1, and less than 1% all three similarities in Q1.2. The highest percentage of missing responses (11.9%) was recorded for Q1.2, which implies that the item was too difficult. The last three items (Q1.3 to Q1.5) required higher order cognitive ability. For these, learners were required to display an understanding of the way the (mechanical) system functions, which is not observable through observation alone. Thus learners needed to know enough about concepts such as 'control mechanisms' (Q1.3), 'stability' (Q1.4) and comparison of the strengths and weaknesses of the different 'design features' (Q1.5). However, less than half of the learners provided the correct answer to each item.

4.2.2. Overall Performance on 'Systems' (Q1)

For each learner, a total score for 'Systems' was derived by summing the individual item scores. The relative contribution of each item to the total score is as follows: Q1.1 = 3 points; Q1.2 = 3 points; Q1.3a&b = 2 points, Q1.4 = 1 point; Q1.5 = 1 point (Total = 10). A missing answer was also calculated as zero.

Figure 4.1 summarises the distribution of the total scores for the 'Systems' component.

Figure 4.1: Overall Performance on 'Systems' (Q1)



Both the mean and median total score for Q1 is 3.51. The mode is 4. No respondent obtained the maximum score of 10. The highest score is 8 out of 10, which less than two percent (1.6%) of learners obtained. The lowest score is 0 out of 10.

As can be seen from Figure 4.1, the scores for Q1 are positively skewed, i.e. the scores lean to the left of the midpoint. Almost three quarters of learners (73%) scored less than the midpoint (5 out of 10). The majority of learners thus have below average scores for this question.

4.2.3. Overall Performance on 'Systems' (Q1) by Gender and Geographic Location

To determine whether boys and girls differ significantly with regard to the total 'Systems' (Q1) scores, a t-test for independent samples was performed. The results of the t-test, together with the mean 'Systems' score for each gender, are reported in Table 4.2.

Table 4.2: Summary of Overall Performance on 'Systems' (Q1) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	58	3.64	1.83	0.760	0.449
Female	67	3.40	1.62		

A slightly higher total mean score was obtained by boys (3.64) than by girls (3.4) for this question. However, the difference in the total mean scores of boys and girls is not statistically significant ($p > 0.05$).

A comparison was also made of the total 'Systems' scores by geographic location. For this, a one-way analysis of variance (ANOVA, or F-test) was conducted. The results are shown in Table 4.3.

Table 4.3: Summary of Overall Performance on 'Systems' (Q1) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
F1	Rural	35	4.26	1.79	5.027	0.008
F2	Urban	34	3.12	1.57		
F3	Peri-urban	57	3.28	1.63		

The results of the F-test show a statistically significant difference. Subsequently, a Bonferroni test was performed to determine between which groups of learners the significant difference occurs. According to the Bonferroni test, learners from the rural school obtained significantly higher scores (4.26) than learners from either the urban (3.12) or peri-urban (3.28) school.

4.3 Performance on 'processing' (q2)

4.3.1. Performance on 'Processing' by Individual Item

The question 2 items assessed the 'Processing' component of the Technology curriculum, i.e. the series of operations in manufacturing. Learners were required to sort waste products into their appropriate categories for recycling. The following question was posed:

> *Recycling is the name given to the process where used and wasted products are broken down and made into something useful. (Many people today prefer to buy a product that is recycled or environmentally friendly because it does less harm to the environment). Below is a list of some things that are often thrown away. Sort them into the correct question for recycling by ticking the correct column for each thing.*

Table 4.4 below summarises the performance per item on 'Processing' (Q2).

Table 4.4: Summary of Responses to 'Processing' (Q2) Items

	Product	N	Percent	Valid Percent
PLANT MATTER	**Potato peels**	*Missing = 0*	*Missing = 0*	
	Wrong	32	25.4	25.4
	Correct	94	74.6	74.6
	Total	126	100	100
	Lettuce leaves	*Missing = 6*	*Missing = 4.8*	
	Wrong	72	57.1	60.0
	Correct	48	38.1	40.0
	Total	120	95.2	100
METAL	**Tins**	*Missing = 12*	*Missing = 9.5*	
	Wrong	47	37.3	36.9
	Correct	67	53.2	63.1
	Total	114	90.5	100
	Cooldrink cans	*Missing = 16*	*Missing = 12.7*	
	Wrong	48	38.1	43.6
	Correct	62	49.2	56.4
	Total	110	87.3	100
PLASTIC	**Plastic bags**	*Missing = 43*	*Missing = 34.1*	
	Wrong	19	15.1	22.9
	Correct	64	50.8	77.1
	Total	83	65.9	100
	Yoghurt cups	*Missing = 19*	*Missing = 15.1*	
	Wrong	61	48.4	57.0
	Correct	46	36.5	43.0
	Total	107	84.9	100
	Egg boxes	*Missing = 15*	*Missing = 11.9*	
	Wrong	39	31.0	57.0
	Correct	72	57.1	43.0
	Total	111	88.1	100
PAPER	**Newspapers**	*Missing = 4*	*Missing = 3.2*	
	Wrong	45	35.7	36.9
	Correct	77	61.1	63.1
	Total	122	96.8	100
GLASS	**Glass cooldrink bottles**	*Missing = 14*	*Missing = 11.1*	
	Wrong	42	33.3	37.5
	Correct	70	55.6	62.5
	Total	112	88.9	100

Note: In the case of 'egg boxes', two correct answers are possible - 'paper' and 'plastic'. The values in the 'Percent' column are expressed out of 126, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 120 for 'Lettuce leaves'.

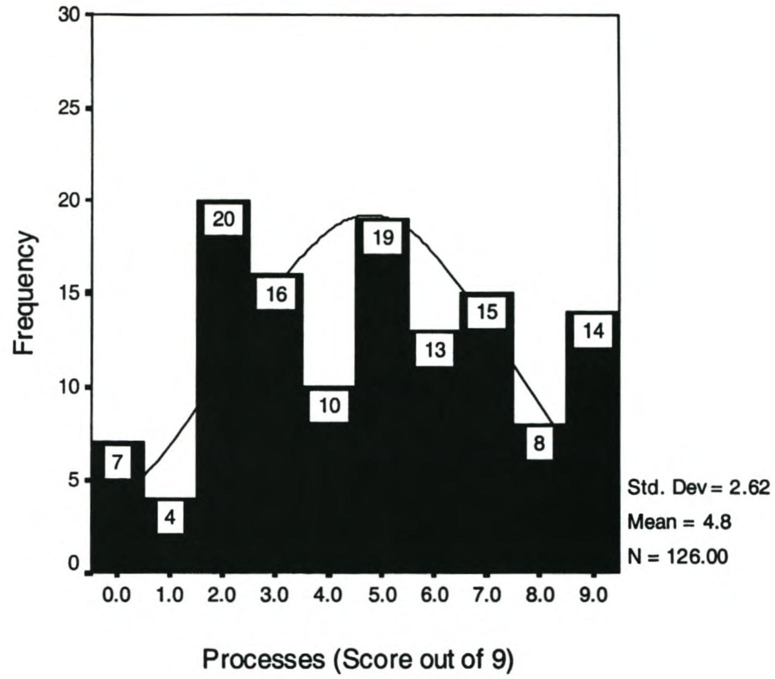
Question 2 ('Processing') was presented to the learners as a grid. In retrospect it appears that this format might have caused some difficulty for Grade 3 learners. For example, for two of the products ('glass cooldrink bottle' and 'plastic bag'), the name of the category to which the products belong ('glass' and 'plastic'), was already contained in the name of the product as supplied in the grid. Yet only about half (55.6% and 50.8% respectively) of the learners were able to correctly categorise these items. The two products ('plastic bags' and 'yoghurt cups') that should be classified under the 'plastic' category, in particular appear to pose problems. This is evidenced by the high number of missing responses observed for both products ('plastic bags' = 34.1% and 'yoghurt cups' = 15.1%). For this reason it will be more informative to consider the 'Percent' column, than the 'Valid Percent' column, in interpreting Table 4.4.

Four of the five categories listed more than one waste product, thus allowing for a comparison within these categories. Of these four categories, the greatest discrepancy occurred within 'plant matter', where 74.6% correctly classified 'potato peels' as plant matter, compared to only 38.1% who could correctly categorise 'lettuce leaves' as such. The waste product 'potato peels' has the highest percentage of correct responses (74.6%). The lowest percentage of correct responses is for 'yoghurt cups' (57%).

4.3.2. Overall Performance on 'Processing' (Q2)

A total score out of 9 was determined for 'Processing' (Q2) by summing the individual item scores (1 = correct; 0 = wrong). The distribution on total scores for 'Processing' is represented in Figure 4.2.

Figure 4.2: Overall Performance on 'Processing' (Q2)



The mean score obtained for 'Processing' is 4.8. The median is 5 and the mode is 2. Approximate equal percentages of learners achieved scores below 5 (45.2%), and 5 and above (54.8%). The full range of the scale was utilised - learners obtained both the lowest (0 out of 9) and the highest (9 out of 9) possible scores. The scores are not normally distributed.

4.3.3. Overall Performance on 'Processing' (Q2) by Gender and Geographic location

The total score on processes was subjected to a t-test for independent samples in order to detect significant differences in the performance of boys and girls. Results are summarised in Table 4.5.

Table 4.5: Summary of Overall Performance on 'Processing' (Q2) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	58	4.36	2.71	-1.692	0.093
Female	67	5.15	2.49		

From Table 4.5 it is evident that, although girls performed slightly better than boys, the difference is not statistically significant ($p > 0.05$).

The results of the F-test with geographic location as independent variable and 'Processing' as dependent variable are given in Table 4.6.

Table 4.6: Summary of Overall Performance on 'Processing' (Q2) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
F1	Rural	35	4.00	2.18	20.701	0.000
F2	Urban	34	6.91	2.23		
F3	Peri-urban	57	3.95	2.36		

A significant difference in scores was found between schools in the three geographic locations. According to the results of the Bonferroni test, the urban school (6.91) performed significantly better than both the rural (4.00) and peri-urban (3.95) school.

Performance on 'materials and equipment' ['m&e'] – (q3)

Performance on 'm&e' (q3) by individual item

Question 3 was a matching exercise, which required learners to match the appropriate implement with the corresponding item for cutting. Pictures of seven cutting implements were supplied on the left, and the names of seven types of materials were supplied on the right. Each one of the 7 implements on the left could only be matched with one of the 7 materials on the right. The question was scored out of 7. The question reads as follows:

Look at the pictures below and read the words on the right side. The tools pictured below (on the left) are designed for cutting. The words (on the right) are materials or things that can be cut. Draw a line from each tool to the material which that tools would be most suited to cut.

Table 4.7 illustrates the performance per item on 'M&E' (Q3).

Table 4.7: Summary of Responses to 'M&E' Items (Q3)

Material	N	Percent	Valid Percent
Wood	*Missing = 10*	*Missing = 7.9*	
Wrong	67	53.2	57.8
Correct	49	38.9	42.2
Total	116	92.1	100
Meat	*Missing = 0*	*Missing = 0*	
Wrong	46	36.5	36.5
Correct	80	63.5	63.5
Total	126	100	100
Grass	*Missing = 1*	*Missing = 0.8*	
Wrong	22	17.5	17.6
Correct	103	81.7	82.4
Total	125	99.2	100
Flowers	*Missing = 8*	*Missing = 6.3*	
Wrong	46	36.5	39.0
Correct	72	57.1	61.0
Total	118	93.7	100
Bread	*Missing = 1*	*Missing = 0.8*	
Wrong	48	38.1	38.4
Correct	77	61.1	61.6
Total	125	99.2	100
Fabric	*Missing = 0*	*Missing = 0*	
Wrong	41	32.5	32.5
Correct	85	67.5	67.5
Total	126	100	100
Cardboard	*Missing = 1*	*Missing = 0.8*	
Wrong	81	64.3	64.8
Correct	44	34.9	35.2
Total	125	99.2	100

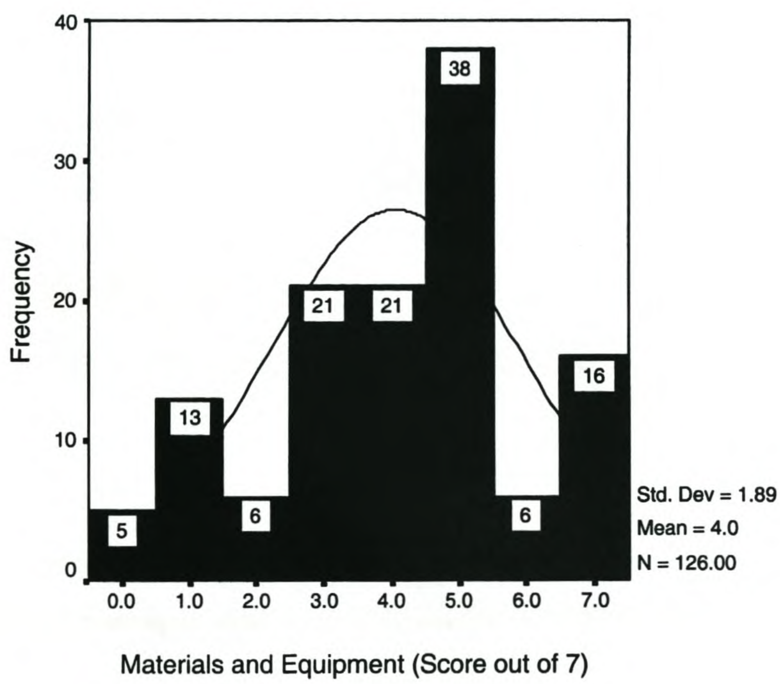
Note: The values in the 'Percent' column are expressed out of 126, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 116 for 'Wood'.

As can be seen from Table 4.7, for many items (4 out of 7) about two-thirds of learners were able to correctly match the appropriate cutting implement with the material. For 'grass', an overwhelming majority of learners (82.4%) were able to match it to a lawnmower. However, for two of the materials, 'wood' and 'cardboard', less than 50% of learners indicated the correct response.

Overall Performance on 'M&E' (Q3)

A total 'M&E' score was calculated by assigning a value of 1 to a correct answer and 0 to an incorrect or missing response. These values were added up to yield a score out of 7. The distribution of the learners' total 'M&E' scores is shown in Figure 4.3.

Figure 4.3: Overall Performance on 'M&E' (Q3)



As can be seen from Figure 4.3, the mean total score for 'M&E' (Q3) is 4.05. The median is 4 and the mode is 5. The distribution appears to be skewed to the left, with most scores above the midpoint.

Overall Performance on 'M&E' (Q3) by Gender and Geographic Location

The total score on 'M&E' was subjected to a t-test for independent samples to detect significant differences in the performance of boys and girls. Table 4.8 contains the results.

Table 4.8: Summary of Overall Performance on 'M&E' (Q3) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	58	4.24	1.87	1.016	0.312
Female	67	3.90	1.92		

From Table 4.8, it is evident that, although boys performed slightly better than girls, the difference in overall 'M&E' scores is not statistically significant ($p > 0.05$).

The results of the F-test with geographic location as independent variable and the total M&E scores as dependent variable are given in Table 4.9.

Table 4.9: Mean total scores for 'M&E'(Q3) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
F1	Rural	35	3.60	1.50	1.378	0.256
F2	Urban	34	4.18	2.19		
F3	Peri-urban	57	4.25	1.90		

For M&E (Q3), no significant differences were found between the rural, urban and peri-urban schools.

Performance on 'materials and components' ['m&c'] – (q4)

Performance on 'M&C' (Q4) by Individual Item

In Question 4, learners were required to identify different parts of a simple radio, and link the labels (supplied above and below the radio), with the relevant part of the diagram. They were posed the following question:

Look carefully at the diagram (supplied above and below the radio) below, and read the words on the right side. Draw a straight line from the label to the correct part of the diagram.

The performance of the learners on the individual items comprising 'M&C' (Q4) is displayed in Table 4.10.

Table 4.10: Summary of Responses to 'M&C' (Q4) Items

Material	N	Percent	Valid Percent
Aerial	*Missing = 0*	*Missing = 0*	
Wrong	10	7.9	7.9
Correct	116	92.1	92.1
Total	126	100	100
Speaker	*Missing = 0*	*Missing = 0*	
Wrong	12	9.5	9.5
Correct	114	90.5	90.5
Total	126	100	100
Dial button	*Missing = 1*	*Missing = 0.8*	
Wrong	94	74.6	75.2
Correct	31	24.6	24.8
Total	125	99.2	100
Frequency display	*Missing = 0*	*Missing = 0*	
Wrong	72	57.1	57.1
Correct	54	42.9	42.9
Total	126	100	100
Tape	*Missing = 0*	*Missing = 0*	
Wrong	49	38.9	38.9
Correct	77	61.1	61.1
Total	126	100	100

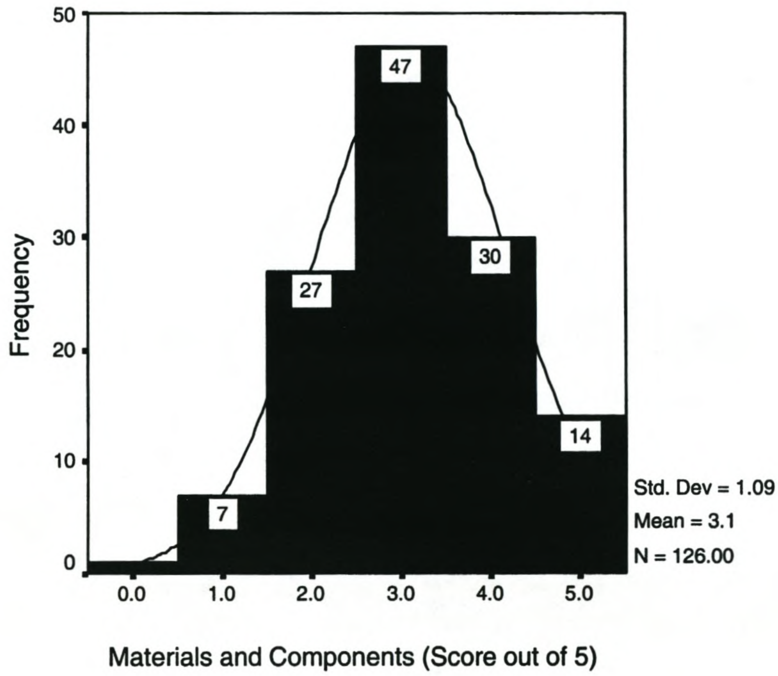
Note: The values in the 'Percent' column are expressed out of 126, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 125 for 'Dial button'.

Table 4.10 reveals a high variance in item scores obtained for Q4. In two items ('aerial' and 'speaker'), most learners responded correctly - 92.1% and 90.5% respectively. On item 5, most learners responded satisfactorily, but scores were considerably lower for item 3 ('dial button') - 24.6% and item 5 ('frequency display') - 42.9%.

Overall Performance on 'M&C' (Q4)

The distribution of learners' total scores for 'M&C' (out of 5) appears in Figure 4.4.

Figure 4.4: Overall Performance on 'M&C' (Q4)



The mean of the overall 'M&C' scores in Figure 4.4 is 3.11, with a median and mode of 3. The distribution is skewed to the left – 72% of respondents have scores of 3 or greater.

Overall Performance on 'M&C' (Q4) by Gender and Geographic Location

A t-test for independent samples was run to determine whether boys and girls differ significantly in their overall performance on 'M&C' (Q4). The results are summarised in Table 4.11.

Table 4.11: Summary of Overall Performance on 'M&C' (Q4) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	58	3.03	1.06	-0.661	0.510
Female	67	3.16	1.12		

Table 4.11 shows that no statistically significant difference exists between boys and girls as far as their overall 'M&C' performance (Q4) is concerned ($p > 0.05$).

The results of the F test with geographic location as independent variable and 'M&C' (Q4) as dependent variable are given in Table 4.12.

Table 4.12: Summary of Overall Performance on 'M&C' (Q4) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
F1	Rural	35	3.80	0.87	12.028	0.000
F2	Urban	34	3.00	1.02		
F3	Peri-urban	57	2.75	1.07		

For 'M&C' (Q4), the group means differ significantly, with rural learners obtaining significantly higher scores than learners from the other two locations (3.80 vs. 3.00 and 2.75 respectively).

Summary of performance on all questions

Lastly, total scores were compared across the four questions. In order to make such a comparison, the scores were expressed as percentages (i.e. out of 100).

Subsequently, mean percentage scores were calculated for each gender and geographic location. Table 4.13 gives the result.

Table 4.13: Mean Total Scores (out of 100) by Gender and Geographic Location

Comparison	Systems (Q1)	Processing (Q2)	M&E (Q3)	M&C (Q4)
Gender				
Male	36.4	48.5	60.6	60.7
Female	34.0	57.2	55.7	63.3
Geographic location				
Rural	42.6	44.4	51.4	76.0
Urban	31.2	76.8	59.7	60.0
Peri-urban	32.8	43.9	60.7	55.1
Total	35.1	52.9	57.8	62.2

From Table 4.13 it is evident that no group has a mean performance score of 50% for 'Systems'. All groups have mean performance scores greater than 50% for 'M&E' and 'M&C'. This means that on two of the four categories learners have 'failed' the test.

Only girls and learners in the urban school have a mean performance score of greater than 50% for 'Processing'. Girls obtained their highest mean score in 'M&C' and boys their highest mean score in both 'M&E' and 'M&C'. This suggests that these questions were of low difficulty, as neither of the independent variables appear to have had any influence on test scores which would differentiate groups.

Learners in the rural school's best performance is in 'M&C'. For learners in the urban and peri-urban schools it is 'Processing' and 'M&E', respectively. Overall (for all groups) the best performance is in 'M&C' and the worst in 'Systems'.

These observations should be viewed together with the results of the statistical tests performed, according to which there is no significant gender difference for any of the four questions. For three questions (with the exception of 'M&E') a significant difference was found for geographic location. For two questions, 'Systems' and 'M&C', the total scores were significantly higher for the rural school than the urban and peri-urban school respectively. A significant difference was found between the urban school and the rural and peri-urban schools respectively.

The following discussion attempts to account for differences in performance on specific categories or questions of the PUT.

Discussion

The main finding for Foundation phase is that significant differences were found for geographic location on three out of the four questions, whereas gender appears to have no effect on scores for any of the questions.

As indicated above, learners from the rural location appeared to have an advantage over learners from both urban and peri-urban locations, at least for two out of the three questions for which significant differences were found, namely 'Systems' and 'M&C'. The significantly higher total scores of rural learners (4.26) vs the total scores of urban (3.12) and peri-urban (3.28) learners for 'Systems' may (at least partially) be attributed to differences in the nature of their respective technological environments. The relatively low levels of mechanisation in rural areas restricts rural learners' access to technology to mainly low-level technology, including leisure items like toys. For example, it is typical that rural learners would have experienced building a kart from scratch. This level of improvisation may not be as common in the experiences of learners from peri-urban and urban areas, who are more likely to play with toys that have already been configured. Although the specific criteria of constructing a kart for a child with no legs may be novel to all, even rural learners, this introduces only one unknown variable into an already familiar (rural) problem-solving context. Thus, rural learners have a relative advantage vis-a-vis urban and peri-urban learners with regard to the 'Systems' component of technological knowledge.

Similarly, rural learners (3.80) scored higher on 'M&C' than did urban (3.00) and peri-urban (2.75) learners respectively. In the same vein, the question on 'M&C' may present difficulties to the urban learners who may only ever have seen or operated a digital version of a radio. The components of the radio may thus not be as easily recognisable to them as to rural learners. Hence, the higher scores for rural learners on this question.

The discussion above also indicates that learners from the urban area performed better on the 'Processing' question. Classifying materials into their appropriate categories for recycling may be a function more familiar to urban than to peri-urban and rural learners. For urban and peri-urban learners, a regular, visible part of urban waste disposal life is the sorting of materials into categories for recycling. Many schools in urban and peri-urban areas participate in corporate waste-management programmes, e.g. the Sappi waste paper project. These commercial production services more consistently target and reach urban than peri-urban or rural locations, and the likelihood that rural learners would be exposed to this is thereby reduced.

At first glance, it would therefore seem that differences due to geographic location are a more significant determinant of performance on the PUT at foundation phase level than are gender differences. The point about the lesser significance of gender in relation to geographic location is true. However, the findings on performance by geographic location should be interpreted with caution.

In the case of the 'Systems' question, even when significant differences were found, the performance of the better-performing group, the rural learners, is still below the midpoint of 50% (5 out of 10). This means that they failed the question. This is of course, is a poor result, regardless of their relatively better performance when compared to that of learners from the other two locations. Indeed, the worst performance overall, i.e. for all groups is on the 'Systems' question.

This fact does not discount the value of analysing significant (geographic or other) differences between groups in cases where learners under-performed on the question. What it does suggest, however, is the likelihood that factors other than geographic location alone may play a role in determining learner understandings of technological 'Systems'.

Similarly, for the 'M&C' and 'M&E' question, although a significant difference was noted in favour of rural learners, all groups passed the question. This may be partly explained by the relative simplicity of the item format i.e. matching pictures from a class of components with pictures form a class of materials ('M&E"), and matching pictures with labels ('M&C').

For the 'Processing' question, on which urban learners performed significantly better than rural and peri-urban learners (6.91 vs 4.00 and 3.9 respectively), the difference is particularly meaningful. In fact, if the midpoint of 4.5 is used as cut-off point, the urban learners' score equals a pass mark, whilst the learners from both the rural and peri-urban locations effectively failed the test. This finding strongly suggests that urban location positively affects the sufficiency of knowledge (as indicated by a pass mark) of the 'Processing' aspect of technological knowledge.

Conclusion

In conclusion, at the Foundation Phase level, geographic location or exposure to relevant technological environments appears to be a significant factor determining the performance of learners on specific questions of the PUT ('Systems', 'Processing' and 'M&C'). However, in some cases, the importance of this difference is reduced because, for example, learners from all locations performed poorly on the particular question. Chapter 5 reports the performance of Intermediate Phase learners on the PUT.

CHAPTER 5
RESULTS FOR INTERMEDIATE PHASE LEARNERS

5.1. Introduction

Whereas Chapter 4 highlighted the effect of exposure to the Technology curriculum on the knowledge and understanding of learners in the Foundation Phase, this chapter reports the results for the Intermediate Phase. The PUT for Intermediate Phase is divided into 7 categories of items, all measuring some aspect of the learners' knowledge/understanding of Technology. These categories relate to Systems and Control (Q1); Processing (Q2); Manufacturing Processes (Q3); Systems and Control: Identification of Tools and Equipment (Q4); Systems and Control: Use of Tools and Equipment (Q5); Structures (Q6); and Electrical Systems (Q7).

For each category the learner performance by individual item will be presented, followed by learner performance on the total set of items. There is also a breakdown of the total score by gender and geographic location.

5.2. Performance on systems and control ['systems'] – (q1)

5.2.1 Performance on 'Systems' (Q1) by Individual Item

The first category of items on 'Systems' (Q1) was prefaced with the following statement:

> *In a far off land where there are many poor people, there lives a little boy called Jonas. He is a kind and sweet boy and everyone in the village likes him. The problem is, Jonas cannot walk. These go-karts were built by his friends to help him get around. Look carefully at the pictures and answer the following questions.*

Table 5.1 reports the performance of the Intermediate Phase learners on the five items that comprise the 'Systems' component.

Table 5.1: Summary of Responses to 'Systems' (Q1) Items

Item	N	Percent	Valid percent
Q1.1: In what ways are A and B the same?	*Missing = 3*	*Missing = 1.6*	
Wrong	28	15.4	15.6
1 Correct	56	30.8	31.3
2 Correct	65	35.7	36.3
3 Correct	30	16.4	16.8
Total	179	98.4	100
Q1.2: In what ways are A and C the same?	*Missing = 4*	*Missing = 2.2*	
Wrong	31	17.0	17.4
1 Correct	91	50.0	51.1
2 Correct	50	27.5	28.1
3 Correct	6	3.3	3.4
Total	178	97.8	100
Q1.3a: Is one of the go-karts more easily steered than the others? If so, which one? (Circle A, B or C)	*Missing = 10*	*Missing = 5.5*	
Wrong	62	34.1	36.0
Correct	110	60.4	64.0
Total	172	94.5	100
Q1.3b: Why?	*Missing = 5*	*Missing = 4.5*	
Wrong	77	70.0	73.3
Correct	28	25.5	26.7
Total	105	95.5	100
Q1.4: Which one is the least stable and therefore more likely to turn over?	*Missing = 19*	*Missing =10.4*	
Wrong	95	52.2	58.3
Correct	68	37.4	41.7
Total	163	89.6	100
Q1.5: Choose the go-kart that you think is the best overall design, and circle it in the pictures above.	*Missing = 13*	*Missing = 7.1*	
Wrong	73	40.1	43.2
Correct	96	52.7	56.8
Total	169	92.9	100

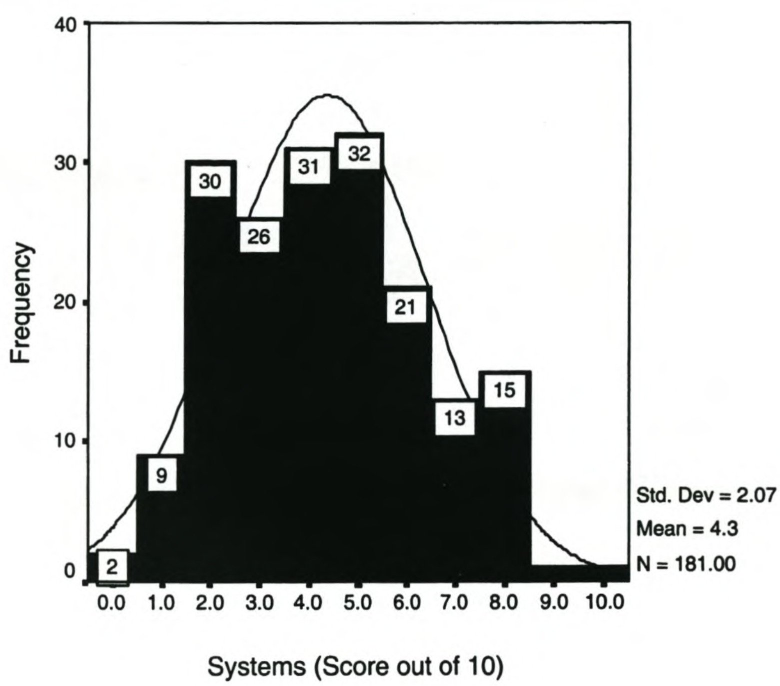
Note: The values in the 'Percent' column are expressed out of 182 (with the exception of Q1.3b, which is based on the number of learners who answered Q1.3a correctly, namely 110). The values in the 'Valid percent' column were calculated by using the valid totals for each item, e.g. 179 for Q1.1, 178 for Q1.2, etc.

For two items in Table 5.1 (Q1.3a and Q1.5) more than half of the learners provided the correct answer. Both these items required higher order cognitive ability. For the two items that required lower order cognitive ability (Q1.1 and Q1.2), the majority of learners only provided partially correct answers.

5.2.2. Overall Performance on 'Systems' (Q1)

For each learner, a total score for 'Systems' was derived by summing the individual item scores. The relative contribution of each item to the total score is as follows: Q1.1 = 3 points; Q1.2 = 3 points; Q1.3a&b = 2 points; Q1.4 = 1 point; Q1.5 = 1 point (Total = 10). Missing answers were scored as zero. (Except in the case of one respondent who left all the items for Q1 unanswered; hence N = 181 for the total 'Systems' scores.) Figure 5.1 summarises the distribution of the total scores for the 'Systems' component.

Figure 5.1: Overall Performance on 'Systems' (Q1)



The mean total score for Q1 is 4.35, with a median of 4 and a mode of 5. Although the scores cover the full scale range, i.e. from 0 to 10, the majority of learners (72%) obtained scores of 5 and less.

5.2.3 Overall Performance on 'Systems' (Q1) by Gender and Geographic Location

To determine whether boys and girls differ significantly with regard to the total 'Systems' (Q1) scores, a t-test for independent samples was performed. The results of the t-test are summarised in Table 5.2.

Table 5.2: Summary of Overall Performance on 'Systems' (Q1) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	70	4.67	2.08	1.753	0.081
Female	108	4.12	2.03		

According to Table 5.2 boys and girls do not differ significantly with regard to their total 'Systems' scores ($p > 0.05$).

The results of the ANOVA test, which compares the total 'Systems' (Q1) scores by geographic location, are given in Table 5.3. The comparison is between 'urban' and 'rural', with the urban component broken down into three subtypes: middle class, 'poor white' and township.

Table 5.3: Summary of Overall Performance on 'Systems' (Q1) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	5.47	1.96	4.724	0.003
I2	Urban (poor white)	53	4.04	2.28		
I3	Urban (township)	51	4.14	1.98		
I4	Rural	41	4.02	1.68		

According to Table 5.3 the overall performance scores on 'Systems' differ significantly by geographic location ($p < 0.05$). More specifically, a Bonferroni test has shown that learners in the urban, middle class school obtained significantly higher scores (5.47) than learners in the other urban and rural schools.

5.3 Performance on 'processing' (q2)

5.3.1. Performance on 'Processing' (Q2) by Individual Item

The Question 2 items assessed the 'Processing' component of the Technology curriculum, i.e. the series of operations in manufacturing. Learners were required to sort waste products into their appropriate categories for recycling. The following question was posed:

> *Recycling is the name given to the process where used and wasted products are broken down and made into something useful. (Many people today prefer to buy a product that is recycled or environmentally friendly because it does less harm to the environment). Below is a list of some things that are often thrown away. Sort them into the correct question for recycling by ticking the correct column for each thing.*

Table 5.4 below summarises the performance per item on 'Processing' (Q2).

Table 5.4: Summary of Responses to 'Processing' (Q2) Items

	Product	N	Percent	Valid Percent
PLANT MATTER	**Potato peels**	*Missing = 5*	*Missing = 2.7*	
	Wrong	20	11.0	11.3
	Correct	157	86.3	88.7
	Total	177	97.3	100
	Lettuce leaves	*Missing = 13*	*Missing = 7.1*	
	Wrong	25	13.1	14.8
	Correct	144	79.1	85.2
	Total	169	92.9	100
METAL	**Tins**	*Missing = 9*	*Missing = 4.9*	
	Wrong	33	18.1	19.1
	Correct	140	76.9	80.9
	Total	173	95.1	100
	Cooldrink cans	*Missing = 19*	*Missing = 10.4*	
	Wrong	32	17.6	19.6
	Correct	131	72.0	80.4
	Total	163	89.6	100
PLASTIC	**Plastic bags**	*Missing = 14*	*Missing = 7.7*	
	Wrong	13	7.1	7.7
	Correct	155	85.2	92.3
	Total	168	92.3	100
	Yoghurt cups	*Missing = 23*	*Missing = 12.6*	
	Wrong	39	21.4	24.5
	Correct	120	65.9	75.5
	Total	159	87.4	100
	Egg boxes	*Missing = 25*	*Missing = 13.7*	
	Wrong	12	6.6	7.6
	Correct	145	79.7	92.4
	Total	157	86.3	100
PAPER	**Newspapers**	*Missing = 3*	*Missing = 1.6*	
	Wrong	8	4.4	4.5
	Correct	171	94.0	95.5
	Total	179	98.4	100
GLASS	**Glass cooldrink bottles**	*Missing = 22*	*Missing = 12.1*	
	Wrong	28	15.4	17.5
	Correct	132	72.5	82.5
	Total	160	87.9	100

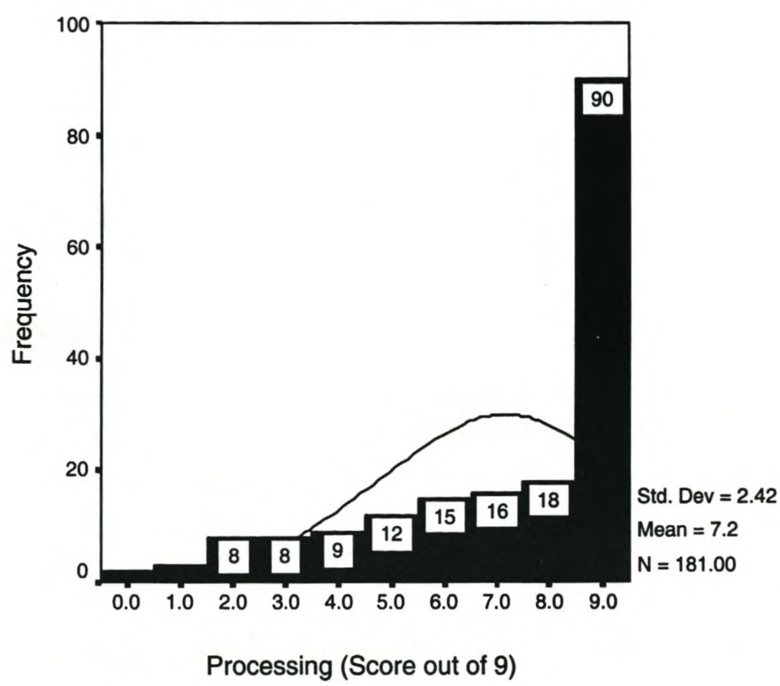
Note: In the case of 'egg boxes', two correct answers are possible - 'paper' and 'plastic'. The values in the 'Percent' column are expressed out of 182, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 177 for 'Potato peels'.

As can be seen in Table 5.4, more than 10% of learners did not attempt 4 of the 9 items on 'Processing' ('Cooldrink cans', 'Yoghurt cups', 'Egg boxes' and 'Glass cooldrink bottles'). The largest number of missing responses was recorded for the question on 'Egg boxes' (13.7%). Nevertheless, the larger majority of respondents provided the correct response to each item (the percentages of correct responses in the 'valid percent' column range between 75.5% and 95.5%).

5.3.2. Overall Performance on 'Processing' (Q2)

A total score out of 9 was calculated for 'Processing' (Q2) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were scored as zero. (Except for one respondent who left all the items for Q2 unanswered; hence N = 181 for the total 'Processing' scores.) The distribution of total scores is given in Figure 5.2.

Figure 5.2: Overall Performance on 'Processing' (Q2)



The mean score for 'Processing' is 7.15, which lies very close to the positive end of the scale (9). The median and mode are 8 and 9, respectively. Moreover, 50% of respondents got the maximum total score for 'Processing', which indicates that the learners experienced little difficulty in answering this question.

5.3.3. Overall Performance on 'Processing' (Q2) by Gender and Geographic location

To detect significant gender differences, the total scores on 'Processing' were subjected to a t-test for independent samples. Results are summarised in Table 5.5.

Table 5.5: Summary of Overall Performance on 'Processing' (Q2) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	71	6.70	2.49	-2.040	0.043
Female	107	7.46	2.36		

According to Table 5.5 girls obtained significantly higher scores than boys on 'Processing' ($p < 0.05$).

The results of the F-test with geographic location as independent variable and 'Processing' as dependent variable are given in Table 5.6.

Table 5.6: Summary of Overall Performance on 'Processing' (Q2) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	8.72	0.88	36.855	0.000
I2	Urban (poor white)	53	8.62	1.36		
I3	Urban (township)	51	5.92	2.46		
I4	Rural	41	5.41	2.34		

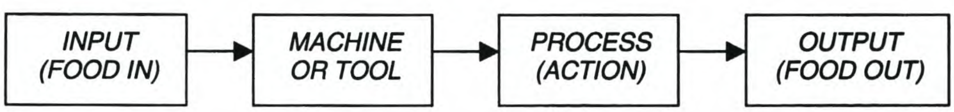
Schools in the four geographic locations have significantly different 'Processing' scores, as seen in Table 5.6 ($p < 0.05$). According to the results of the Bonferroni test, the urban middle class and urban 'poor white' schools scored significantly higher than both the urban township and rural schools. However, no significant difference was found between the urban middle class and urban 'poor white' schools, or between the urban township and rural schools.

5.4. Performance on 'manufacturing processes' ['manufacturing'] – (q3)

5.4.1. Performance on 'Manufacturing' (Q3) by individual item

Question 3 items assessed the 'Manufacturing' component of the Technology curriculum. According to the curriculum, learners are required to demonstrate an understanding of the activity of processing raw materials into refined materials and products, with waste products as a by-product, in the context of bio-technology, manufacturing, agriculture or mining. Question 3 items focussed on the manufacturing process. The question was prefaced by the following:

Processing food usually involves the following steps:



Complete the table below so that the machine or tool and the process will produce the correct output.

More specifically, the learners were given four inputs together with a corresponding output (cream – butter; egg – omelette; meat – mince; and potatoes – chips). Options for the 'Machine' or 'Process' involved were also provided, from which the learners had to select the correct option(s).

Table 5.7 summarises the performance per item on 'Manufacturing' (Q3).

Table 5.7: Summary of Responses to 'Manufacturing' (Q3)

Item	Machine			Process		
	N	Percent	Valid Percent	N	Percent	Valid Percent
Cream	*Missing = 44*	*Missing = 24.2*		*Missing = 117*	*Missing = 64.3*	
Wrong	130	71.4	94.2	0	0	0
Correct	8	4.4	5.8	65	35.7	100
Total	138	75.8	100	65	35.7	100
Egg	*Missing = 9*	*Missing = 4.9*		*Missing = 6*	*Missing = 3.3*	
Wrong	107	58.8	61.8	59	32.4	33.5
Correct	66	36.3	38.2	117	64.3	66.5
Total	173	95.1	100	176	96.7	100
Meat	*Missing = 12*	*Missing = 6.6*		*Missing = 17*	*Missing = 9.3*	
Wrong	106	58.2	62.4	99	54.4	60.0
Correct	64	35.2	37.4	66	36.3	40.0
Total	170	93.4	100	165	90.7	100
Potatoes	*Missing = 26*	*Missing = 14.3*		*Missing = 15*	*Missing = 8.2*	
Wrong	79	43.4	50.6	134	73.6	80.2
Correct	77	42.3	49.4	33	18.1	19.8
Total	156	85.7	100	167	91.8	100

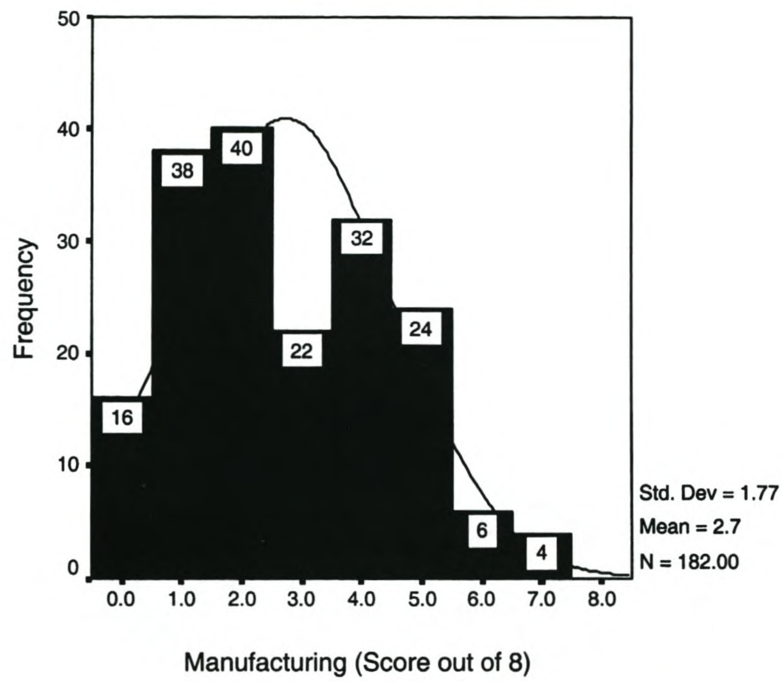
Note: The values in the 'Percent' column are expressed out of 182, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 173 for 'Egg – Machine' and 176 for 'Egg – Process'.

In Table 5.7 the manufacture of butter from cream presented the greatest difficulty to the learners (both the 'machine' and 'process' involved). This is evident from the large number of missing responses and the small number of correct responses. Also, the process involved in making chips from potatoes yielded a large number of incorrect responses. For only one item did the number of correct responses outmatched the number of incorrect responses: the process involved in making omelettes by using eggs.

5.4.2. Overall Performance on 'Manufacturing' (Q3)

A total 'Manufacturing' score was calculated by assigning a value of 1 to a correct answer and 0 to an incorrect or missing response. These values were added up to yield a score out of 8. The distribution of the learners' total 'Manufacturing' scores is shown in Figure 5.3.

Figure 5.3: Overall Performance on 'Manufacturing'



The distribution of 'Manufacturing' scores is positively skewed (i.e. the majority of scores fall to the left of the midpoint), with a mean of 2.73 and a median and mode of 2. No learner obtained the maximum score of 8.

5.4.3. Overall Performance on 'Manufacturing' (Q3) by Gender and Geographic location

The total score on 'Manufacturing' was subjected to a t-test for independent samples in order to investigate gender differences. Table 5.8 contains the results.

Table 5.8: Summary of Overall Performance on 'Manufacturing' (Q3) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	71	2.66	1.45	-0.346	0.730
Female	108	2.75	1.95		

Boys and girls do not differ significantly in their total 'Manufacturing' scores, according to Table 5.8. The results of the F-test for geographic location appear in Table 5.9.

Table 5.9: Summary of Overall Performance on 'Manufacturing' (Q3) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	3.53	1.83	12.728	0.000
I2	Urban (poor white)	53	3.15	1.81		
I3	Urban (township)	52	1.60	1.36		
I4	Rural	41	2.90	1.46		

A significant difference is evident in the performance of learners on the 'Manufacturing' subtest, as far as the geographic location of the schools are concerned ($p < 0.05$). More specifically, according to the results of a Bonferroni test, the scores of the learners in the township school are significantly lower than those of learners in the other locations.

5.5. Performance on 'systems and control: identification of tools and equipment' ['id-t&e'] – (q4)

5.5.1. Performance on 'ID-T&E' (Q4) by Individual Item

The items on 'ID-T&E' (Q4) assessed learner ability to identify mechanical tools and equipment. Learners were required to correctly identify the picture of 6 mechanical parts presented in the table. The following question prefaced the table:

The mechanisms pictured below can increase force and decrease speed or distance travelled. Look at the diagrams below, and draw a line linking each of the diagrams (pictures) to the correct label.

Table 5.10 presents the performance of learners on individual items for Q4.

Table 5.10: Summary of Responses to 'ID-T&E' (Q4) Items

Item	N	Percent	Valid Percent
Chassis	*Missing = 23*	*Missing = 12.6*	
Wrong	78	42.9	49.1
Correct	81	44.5	50.9
Total	159	87.4	100
Chain and Sprocket	*Missing = 8*	*Missing = 4.4*	
Wrong	32	17.6	18.4
Correct	142	78.0	81.6
Total	174	95.6	100
Bevel Gear	*Missing = 16*	*Missing = 8.8*	
Wrong	96	52.7	57.8
Correct	70	38.5	42.2
Total	166	91.2	100
Wheel and Axle	*Missing = 10*	*Missing = 5.5*	
Wrong	40	22.0	23.3
Correct	132	72.5	76.7
Total	172	94.5	100
Worm and Pinion Gear	*Missing = 16*	*Missing = 8.8*	
Wrong	100	54.9	60.2
Correct	66	36.3	39.8
Total	166	91.2	100
Belt and Pulley	*Missing = 11*	*Missing = 6.0*	
Wrong	39	21.4	22.8
Correct	132	72.5	77.2
Total	171	94.0	100

Note: The values in the 'Percent' column are expressed out of 182, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 159 for 'Chassis' and 174 for 'Chain and Sprocket'.

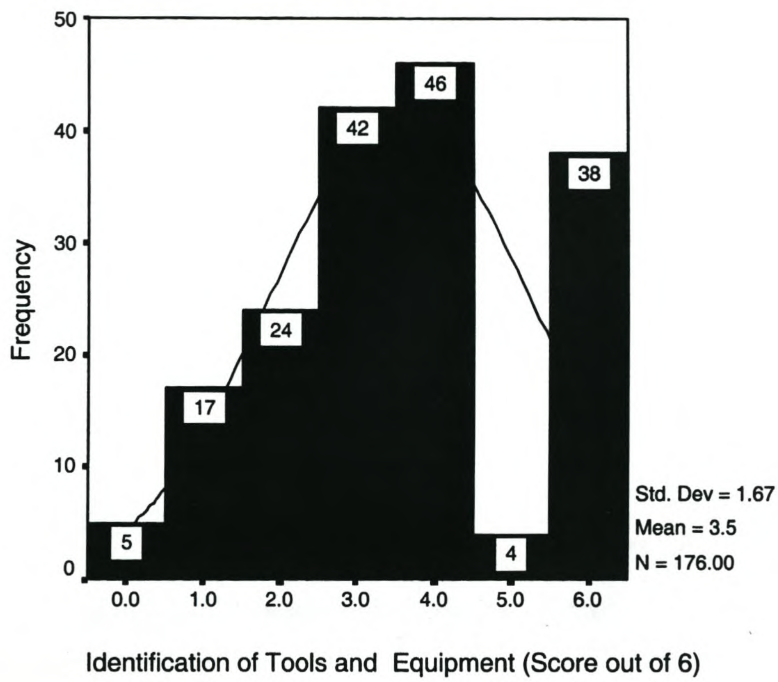
The performance on 'ID-T&E' in Table 5.10 shows that the highest number of missing responses was recorded for 'chassis' (12.6%). This item, together with 'bevel gear' and 'worm and pinion gear' presented the greatest difficulty to the learners, as 50% and less correctly identified these parts. On the other hand, more than three-quarters of learners correctly identified 'chain and sprocket', 'wheel and axle' and 'belt and pulley'.

5.5.2. Overall Performance on 'ID-T&E' (Q4)

A total score out of 6 was calculated for 'ID-T&E' (Q4) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were also scored as zero. (Except for

6 respondents who left all items for Q4 unanswered; hence N = 176.) The distribution of the learners' total scores for 'ID-T&E' appears in Figure 5.4.

Figure 5.4: Overall performance on 'ID-T&E'



The mean of the distribution is 3.54, with a median and mode of 3.5 and 4, respectively. The distribution is negatively skewed, which means that more learners obtained scores to the higher end of the scale than to the lower end of the scale. Also, the full range of the scale was utilised.

5.5.3. Overall Performance on 'ID-T&E' (Q4) by Gender and Geographic location

The results of the t-test, to investigate whether boys and girls differ significantly with regard to their total 'ID-T&E' scores, are given in Table 5.11.

Table 5.11: Summary of Overall Performance on 'ID-T&E' (Q4) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	69	3.45	1.48	-0.505	0.614
Female	105	3.58	1.80		

As can be seen in Table 5.11, the gender difference in the overall 'ID-T&E' scores is statistically not significant (p > 0.05). The results of the F-test with geographic location as independent variable and the total 'ID-T&E' scores as dependent variable are given in Table 5.12.

Table 5.12: Summary of Overall Performance on 'ID-T&E' (Q4) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	4.50	1.81	11.331	0.000
I2	Urban (poor white)	53	3.87	1.49		
I3	Urban (township)	46	2.61	1.61		
I4	Rural	41	3.32	1.23		

A significant difference was found in the overall 'ID-TEC' performance of schools in the different geographic locations. According to a Bonferroni test, the urban township learners scored significantly lower than learners in both the urban middle class and urban poor white schools (2.61 versus 4.50 and 3.87). Also, the scores of learners in the rural school differ significantly from those of learners in the urban middle class school (3.32 versus 4.50).

5.6. Performance on systems and control: use of tools and equipment– ['use-t&e'] – (q5)

5.6.1. Performance on 'USE-T&E' (Q5) by Individual Item

The items on 'USE-T&E' (Q5) assessed learners' understanding of the operating principles of simple mechanical systems. Four diagrams were displayed (A to D), three with two wheels and one with three wheels. Each diagram had an arrow indicating the direction of movement of at least one wheel. The learners were presented with the following instruction:

Look at the diagrams below. In each case, the left-hand wheel is rotating (turning) in a clockwise direction (to the right). Draw an arrow to indicate the direction the right hand wheel is turning. [In D, indicate (show) the direction that the other two wheels are turning.]

An additional item follows the set of diagrams, which reads:

*In two of the diagrams, the direction of movement changes (*learners were asked to indicate which diagrams*). In your own words, explain how this happens.*

Table 5.13 illustrates the performance per item on 'USE-T&E' (Q5).

Table 5.13: Summary of Responses to 'USE-T&E' (Q5) Items

	Item	N	Percent	Valid Percent
Direction that wheels are turning	**A: Wheels and Band (uncrossed)**	*Missing = 46*	*Missing = 25.3*	
	Wrong	19	10.4	14.0
	Correct	117	64.3	86.0
	Total	136	74.7	100
	B: Wheels and Band (crossed)	*Missing = 46*	*Missing = 25.3*	
	Wrong	30	16.5	22.1
	Correct	106	58.2	77.9
	Total	136	74.7	100
	C: Two wheels with grooves	*Missing = 41*	*Missing = 22.5*	
	Wrong	42	23.1	29.8
	Correct	99	54.4	70.2
	Total	141	77.5	100
	D1: Three wheels with grooves (Middle wheel)	*Missing = 54*	*Missing = 29.7*	
	Wrong	52	28.6	40.6
	Correct	76	41.8	59.4
	Total	128	70.3	100
	D2: Three wheels with grooves (Last wheel)	*Missing = 41*	*Missing = 22.5*	
	Wrong	45	24.7	31.9
	Correct	96	52.7	68.1
	Total	141	77.5	100
Additional	**In which two diagrams do the direction of movement change?**	*Missing = 25*	*Missing = 13.7*	
	Wrong	16	8.8	10.2
	1 Correct	106	58.2	67.5
	2 Correct	35	19.2	22.3
	Total	157	86.3	100
	Why do the direction of movement change?	*Missing = 26*	*Missing = 14.3*	
	Wrong	102	56.0	65.4
	1 Correct	51	28.0	32.7
	2 Correct	3	1.6	1.9
	Total	156	85.7	100

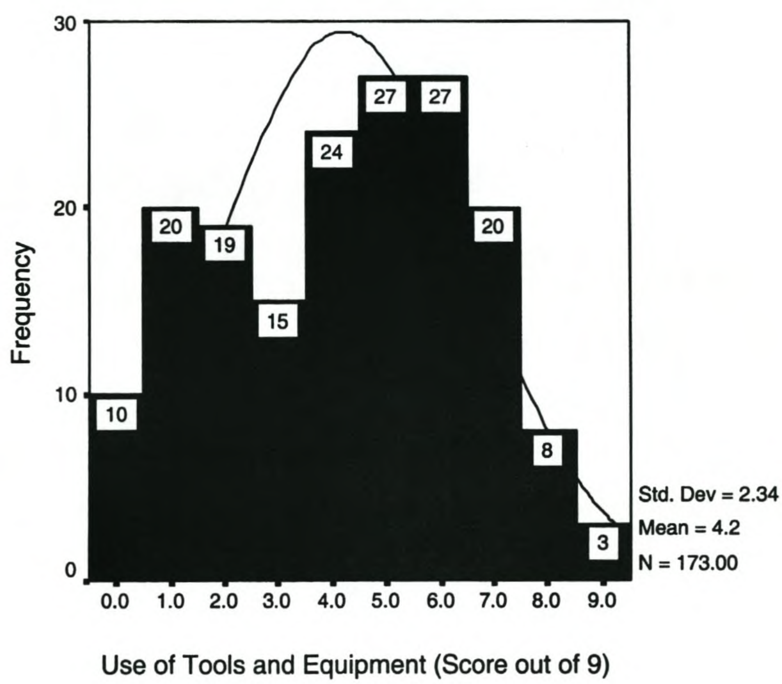
Note: The values in the 'Percent' column are expressed out of 182, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 136 for 'Wheels and band (uncrossed)'.

Almost 25% of the learners did not indicate the direction in which the wheels in diagrams A to D are changing. Given this large number of missing responses, an inspection of the values in the 'Percent' column rather than those in the 'Valid percent' column is appropriate. For only one of the five wheels (A to D2) did less than 50% of learners give the wrong response (D1). However, for three of the wheels (B, C, D2) the percentages of correct responses do not appear to be markedly above 50%. As far as the additional items are concerned, more respondents (19.2%) correctly indicated in which diagrams the direction of movement changes, than explaining in their own words why this is happening (1.6%). These percentages of correct responses are very low.

5.6.2. Overall Performance on 'USE-T&E' (Q5)

For each learner a total 'USE-T&E' score was derived by summing their responses to the individual items. The relative contribution of each item to the total score was as follows: A to D2 = 1 point each and the two additional items = 2 points each (Total = 9) A missing answer was also calculated as zero. (Except for nine respondents who left all the items unanswered; hence N = 173.). Figure 5.5 summarises the distribution of the total scores for the 'USE-T&E' component.

Figure 5.5: Overall Performance on 'USE-T&E' (Q5)



The mean of the distribution of total 'USE-T&E' scores is 4.2, with a median of 4 and a multiple mode of 5 and 6. The learners utilised the full range of the scale. Also, about equal percentages of learners scored 4 or less (51%) or 5 and more (49%).

5.6.3. Overall Performance on 'USE-T&E' (Q5) by Gender and Geographic location

Table 5.14 contains the result of the t-test that investigated gender differences.

Table 5.14: Summary of Overall Performance on 'USE-T&E' (Q5) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	66	4.30	2.32	0.383	0.702
Female	105	4.16	2.36		

A slightly higher total 'USE-T&E' score was obtained by boys (4.30) than by girls (4.16). However, the difference in the total mean scores of boys and girls is not statistically significant ($p > 0.05$). A comparison was also made of the total 'USE-T&E' scores by the geographic location of the schools. The results of the F-test are reported in Table 5.15.

Table 5.15: Summary of Overall Performance on 'USE-T&E' (Q5) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	5.92	1.83	35.377	0.000
I2	Urban (poor white)	53	4.62	2.15		
I3	Urban (township)	43	1.84	1.54		
I4	Rural	41	4.63	1.74		

According to Table 5.15 the total 'USE-T&E' scores of the learners differ significantly by the geographic location of the schools. All means differ significantly from one another, with the exception of the difference between learners in the urban (poor white) and rural schools. The highest mean score was reported in the urban middle class school and the lowest in the township.

5.7. Performance on 'electrical and electronic systems' ['electrical systems'] – (q6)

5.7.1. Performance on 'Electrical Systems' (Q6) by Individual Item

The items for Question 6 assess learner understandings of 'Electrical Systems'. Learners were presented with two diagrams - one connected in series and the other in parallel. The question read as follows:

In each of these circuits pictured below, the light will glow when the switch closes the circuit.

A series of questions relating to the circuits were then posed. Table 5.16 illustrates the performance per item on 'Electrical Systems'.

Table 5.16: Summary of Responses to 'Electrical Systems' (Q6) Items

Item	N	Percent	Valid Percent
6.1: What is the source of energy that allows the light to glow?	*Missing = 5*	*Missing = 2.7*	
Wrong	69	37.9	39.0
Correct	108	59.3	61.0
Total	177	97.3	100
6.2: In which circuit will the light glow the brightest?	*Missing = 12*	*Missing = 6.6*	
Wrong	96	52.7	56.5
Correct	74	40.7	43.5
Total	170	93.4	100
6.3: Why	*Missing = 3*	*Missing = 4.1*	
Wrong	61	82.4	85.9
Correct	10	13.5	14.1
Total	71	95.9	100
6.4: What will happen if we break the circuit at X?	*Missing = 23*	*Missing = 12.6*	
Wrong	87	47.8	54.7
Correct	72	39.6	45.3
Total	159	87.4	100
6.5: What will happen if we break the circuit at Y?	*Missing = 31*	*Missing = 17.0*	
Wrong	107	58.8	70.9
Correct	44	24.2	29.1
Total	151	83.0	100

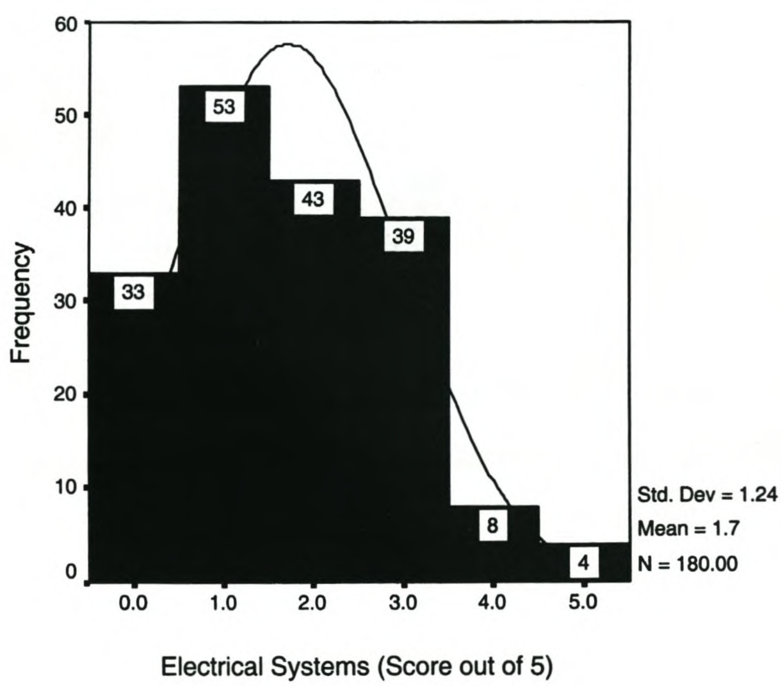
Note: The values in the 'Percent' column are expressed out of 182 (with the exception of Q6.3, which is based on the number of learners who answered Q6.2 correctly, namely 74). The values in the 'Valid percent' column were calculated by using the valid totals for each item, e.g. 177 for Q6.1 and 170 for Q6.2.

The missing responses in Table 5.16 range from 2.7% to 17%. These, together with the large number of wrong answers given, imply that the items on 'Electrical Systems' were probably too difficult for the Intermediate Phase learners. In fact, for four of the five items less than half of the respondents provided the correct answer. The exception is Q6.1, where 61% of 177 learners stated the correct answer.

5.7.2. Overall Performance on 'Electrical Systems' (Q6)

A total score out of 5 was determined for 'Electrical Systems' by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were scored as zero. (One respondent left all the items for Q6 unanswered; hence N = 181.) The distribution on total scores for 'Electrical Systems' is represented in Figure 5.6.

Figure 5.6: Overall Performance on 'Electrical Systems' (Q6)



The mean total score for 'Electrical Systems' is 1.71, with a median of 2 and a mode of 1. The scores are positively skewed, meaning that the majority of scores tend to cluster at the lower end of the scale (72% of learners had a score of 2 or less out of 5).

5.7.3. Overall Performance on 'Electrical Systems' (Q6) by Gender and Geographic location

To investigate significant gender differences, the total scores on 'Electrical Systems' were subjected to a t-test for independent samples. Results are summarised in Table 5.17.

Table 5.17: Summary of Overall Performance on 'Electrical Systems' (Q6) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	69	1.51	1.27	-1.913	0.057
Female	108	1.87	1.21		

No significant gender difference is evident in Table 5.17 ($p > 0.05$). Table 5.18. gives the results of the F-test with geographic location as independent variable and the total 'Electrical Systems' scores as dependent variable.

Table 5.18: Summary of Overall Performance on 'Electrical Systems' (Q6) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
I1	Urban (middle class)	36	2.28	1.37	17.066	0.000
I2	Urban (poor white)	53	2.17	1.09		
I3	Urban (township)	50	0.82	0.87		
I4	Rural	41	1.71	1.12		

The significant difference in Table 5.18 is primarily because of a lower mean score on 'Electrical Systems' for urban township learners, compared to the scores of the learners in the other locations.

5.8. Performance on structures (q7)

5.8.1. Performance on Structures (Q7) by Individual Item

Question 7 Items assess learner understanding of 'Structures'. The first two of six items (Q7.1 and Q7.2) assessed learner understanding of the effect of loads on the stability of structures. The latter four items (Q7.3 to Q7.6) assessed their understanding of the characteristics of basic structural components. Table 5.19 illustrates the performance per item on 'Structures'.

Table 5.19: Summary of Responses to 'Structures' (Q7) Items

Item	N	Percent	Valid Percent
7.1: Which beam is most likely to sag and bend if the weight of the load is increased? Circle A or B	*Missing = 7*	*Missing = 3.8*	
Wrong	41	22.5	23.4
Correct	134	73.6	76.6
Total	175	96.2	100
7.2: Why?	*Missing = 4*	*Missing = 3.0*	
Wrong	65	48.5	50
Correct	65	48.5	50
Total	130	97	100
7.3: Which (beam) is the strongest? Circle C, D or E	*Missing = 13*	*Missing = 7.1*	
Wrong	28	15.4	16.6
Correct	141	77.5	83.4
Total	169	92.9	100
7.4: Why?	*Missing = 10*	*Missing = 7.1*	
Wrong	81	57.4	61.8
Correct	50	35.5	38.2
Total	131	92.9	100
7.5: Which (beam) is the weakest? Circle C, D or E	*Missing = 20*	*Missing = 11*	
Wrong	29	15.9	17.9
Correct	133	73.1	82.1
Total	162	89.0	100
7.6: Why?	*Missing = 5*	*Missing = 3.8*	
Wrong	82	61.7	64.1
Correct	46	34.6	35.9
Total	128	96.2	100

Note: The values in the 'Percent' column are expressed out of 182, with the exception of Q7.2, Q7.4 and Q7.6, which are based on the number of learners who answered the preceding items correctly.

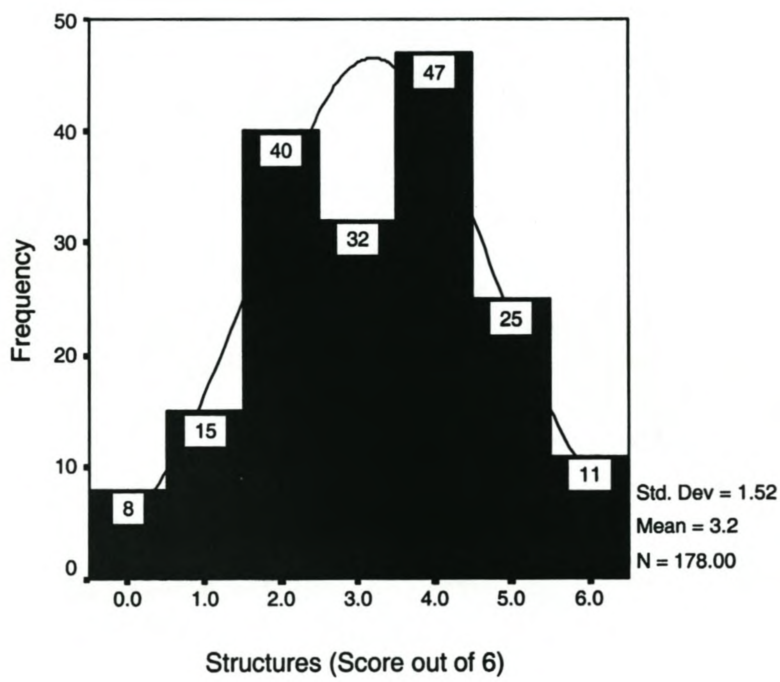
Table 5.19 reveals an interesting pattern that whereas about three quarters of learners correctly circled an option (Q7.1, Q7.3 and Q7.5), more than half of the learners failed to correctly explain their motivation for circling the option.

5.8.2. Overall Performance on Structures (Q7)

A total score out of 6 was calculated for 'Structures' (Q7) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were also scored as zero. (Except for 4 respondents who left all items for Q7 unanswered; hence N = 178.)

The distribution of the learners' total scores for 'Structures' appears in Figure 5.7.

__Figure 5.7: Overall Performance on 'Structures' (Q7)__



The mean total score for 'Structures' is 3.2, with a median of 3 and a mode of 4. The scores are somewhat negatively skewed, implying that there is a clustering of scores at the higher end of the scale.

5.8.2. Overall Performance on 'Structures' (Q7) by Gender and Geographic Location

A t-test was done to compare the mean 'Structures' scores of boys and girls for statistical significance.

Table 5.20: Summary of Overall Performance on 'Structures' (Q7) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	69	3.16	1.40	-0.403	0.687
Female	108	3.25	1.60		

According to Table 5.20 boys and girls do not differ significantly regarding their total 'Structure' scores (p > 0.05). The comparison for geographic location is given in Table 5.21.

Table 5.21: Summary of Overall Performance on Structures (Q7) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	P
I1	Urban (middle class)	35	3.80	1.55	6.367	0.000
I2	Urban (poor white)	53	3.25	1.33		
I3	Urban (township)	50	2.50	1.43		
I4	Rural	41	3.49	1.57		

The significant difference in Table 5.21 primarily lies between learners in the township and urban middle class schools (2.50 versus 3.80), as well as between learners in the township and rural schools (2.50 versus 3.49).

5.9. Summary of performance on all questions

Finally, total scores were compared across the seven questions. In order to make the scores comparable, percentages were calculated (i.e. scores out of 100), and the mean performance noted for gender and geographic location. Table 5.22 summarises the result.

Table 5.22: Mean Total Scores (out of 100) by Gender and Geographic Location

Comparison	Systems (Q1)	Processing (Q2)	Manufacturing (Q3)	ID-T&E (Q4)	USE-T&E (Q5)	Electrical Systems (Q6)	Structures (Q7)
Gender							
Male	46.7	74.5	33.3	57.9	47.8	30.1	52.7
Female	41.2	82.9	34.4	59.7	46.2	37.4	54.2
Geographic location							
Urban (middle class)	54.7	96.9	44.1	75.0	65.7	45.6	63.3
Urban (poor white)	40.4	95.8	39.4	64.5	51.4	43.4	54.2
Urban (township)	41.4	65.8	20.0	43.5	20.4	43.4	54.2
Rural	40.2	60.2	36.3	55.3	51.5	34.1	58.1
Total	43.5	79.5	34.1	60.0	46.7	34.2	53.4

From Table 5.22 it is evident that:

All groups have mean performance scores above 50% for 'Processing' and 'Structures'. All groups have mean performance scores less than 50% for 'Manufacturing' and 'Electrical Systems'. The urban, middle class learners have the highest mean on all the questions. The urban township learners have the lowest mean on four out of the seven questions, whereas the rural school learners have the lowest mean on three questions. Overall (for all groups) the best performance is in 'Processing' and the worst in 'Manufacturing' and 'Electrical Systems'.

As can be seen in the summary above, a significant gender difference was found for 'Processing' (girls performed better than boys). These observations are supplemented by the results of the statistical tests performed, which can be summarised as follows:

For all questions a significant difference was found for geographic location, and in the following direction:

• 'Systems'	:	Urban middle class > Rest
• 'Processing'	:	Urban middle class > Urban township
		Urban middle class > Rural
		Urban poor white > Urban township
		Urban poor white > Rural
• 'Manufacturing'	:	Urban township < Rest
• 'ID-T&E'	:	Urban middle class > Urban township
		Urban middle class > Rural
		Urban poor white > Urban township
• 'USE-T&E'	:	Urban middle class > Rest
		Urban poor white > Urban township
		Rural > Urban township
•'Electrical Systems'	:	Urban township < Rest
• 'Structures'	:	Urban middle class > Urban township
		Rural > Urban Township

5.10. Discussion

The most pertinent finding at the Intermediate Phase level is that geographic location was a significant correlate for all questions, whilst gender differences were significant for only one question ('Processing').

With regard to geographic location, the urban middle class have the highest mean on all questions. On two questions, 'Systems' and 'USE-T&E', this group's performance was significantly higher than all of the other groups'. On three of the questions on which the difference was significant ('Processing', 'ID-T&E' and 'Structures') for a single group, it was only significantly higher than the urban township school. Thus it appears that the most significant differences in performance occur between the urban schools (between the urban middle class school and the township school in particular). This would seem to validate the further classification of schools into socio-economic categories as geographic location alone cannot account for the vast differences in the performance of learners at this level.

However, the fact that significant differences in performance exist even between the poorer socio-economic groups (e.g. between the urban poor white and the urban township, in favour of the poor white on three questions - 'Processing', ID-T&E' and 'USE-T&E') suggests that there is a need to consider factors within these categories which may further differentiate them. Although not tested here, factors such as the existence and types of technology in the home, exposure to technology from peers and parents (occupationally), and differences in the capacity of technology educators, could have an influence on learner knowledge of technology. Of the three schools in the 'urban' category, two of them, the urban middle class and the urban poor white group had significantly higher scores than the rural school. The third 'urban' school, the urban township, in turn performed consistently weaker in comparison to the rural school, whose scores were significantly higher on two relevant questions ('USE-T&E' and 'Structures').

Considering that the urban township school to a large extent draws learners from surrounding informal settlements, whose families are often rural immigrants to the city, we would expect their knowledge of rural technological environments to be similar to that of rural learners. Thus, the finding of a significant difference in their performance on the two questions mentioned above is surprising and certainly difficult to explain.

5.11. Conclusion

To reiterate, the most significant findings pertain to geographic differences (combined with socio-economic environment) between schools. Gender differences appear to play a less significant role at this level, with significance only observed on one question. The crucial question would seem to be whether these variables are sufficient in explaining differences in learner performance on the PUT at the Intermediate Phase level. The next chapter, Chapter 6, examines the performance of learners at the Senior Phase level.

CHAPTER 6
RESULTS FOR SENIOR PHASE LEARNERS

6.1. Introduction

The PUT for the Senior Phase is identical to the PUT for the Intermediate Phase and divided into the same 7 categories of items, measuring various aspects of the learners' knowledge/understanding of Technology. These categories relate to Systems and Control (Q1); Processing (Q2); Manufacturing Processes (Q3); Systems and Control: Identification of Tools and Equipment (Q4); Systems and Control: Use of Tools and Equipment (Q5); Structures (Q6); and Electrical Systems (Q7). For each category, the learner performance by individual item will be presented, followed by learner performance on the total set of items. As before, a breakdown of the total score by gender and geographic location is provided.

6.2. Performance on systems and control ['systems'] – (q1)

6.2.1 Performance on 'Systems' (Q1) by Individual Item

The first category of items on 'Systems' (Q1) was prefaced with the following statement:

> *In a far off land where there are many poor people, there lives a little boy called Jonas. He is a kind and sweet boy and everyone in the village likes him. The problem is, Jonas cannot walk. These go-karts were built by his friends to help him get around. Look carefully at the pictures and answer the following questions.*

Table 6.1 reports the performance of the Intermediate Phase learners on the five items that comprise the 'Systems' component.

Table 6.1: Summary of Responses to 'Systems' (Q1) Items

Item	N	Percent	Valid percent
Q1.1: In what ways are A and B the same?	*Missing = 2*	*Missing = 1.2*	
Wrong	18	11.2	11.3
1 Correct	69	42.9	43.4
2 Correct	53	32.9	33.3
3 Correct	19	11.8	11.9
Total	159	98.8	100
Q1.2: In what ways are A and C the same?	*Missing = 15*	*Missing = 9.3*	
Wrong	42	26.1	28.8
1 Correct	79	49.1	54.1
2 Correct	25	15.5	17.1
3 Correct	0	0.0	0.0
Total	146	90.7	100
Q1.3a: Is one of the go-karts more easily steered than the others? If so, which one? (Circle A, B or C)	*Missing = 10*	*Missing = 6.2*	
Wrong	70	43.5	46.4
Correct	81	50.3	53.4
Total	151	93.8	100
Q1.3b: Why?	*Missing = 6*	*Missing = 7.4*	
Wrong	64	79.0	85.3
Correct	11	13.6	14.7
Total	75	92.6	100
Q1.4: Which one is the least stable and therefore more likely to turn over?	*Missing = 15*	*Missing = 9.3*	
Wrong	67	41.6	45.9
Correct	79	49.1	54.1
Total	149	90.7	100
Q1.5: Choose the go-kart that you think is the best overall design, and circle it in the pictures above.	*Missing = 15*	*Missing = 9.3*	
Wrong	69	42.8	47.3
Correct	77	47.8	52.7
Total	146	90.7	100

Note: The values in the 'Percent' column are expressed out of 161 (with the exception of Q1.3b, which is based on the number of learners who answered Q1.3a correctly, namely 81). The values in the 'Valid percent' column were calculated by using the valid totals for each item, e.g. 159 for Q1.1, 146 for Q1.2, etc.

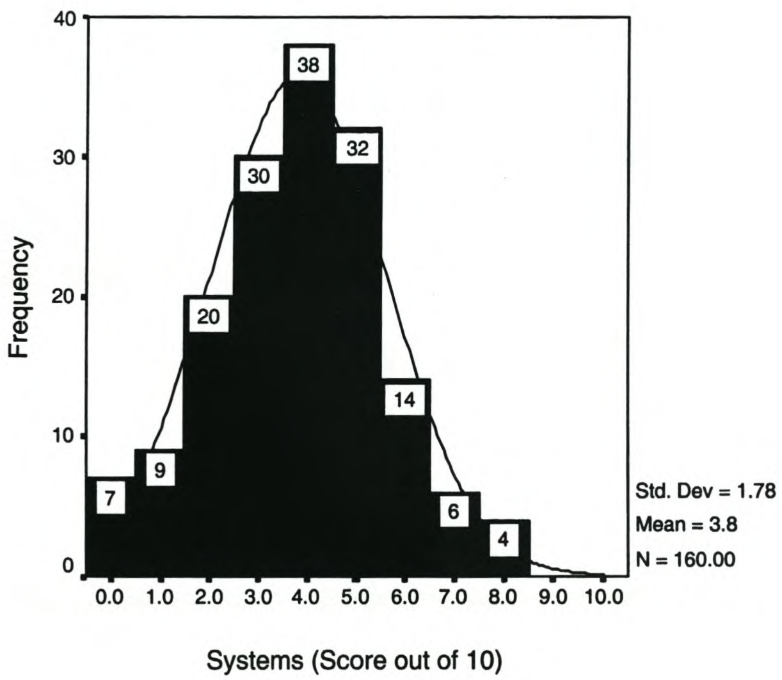
For three items in Table 6.1 (Q1.3a, Q1.4 and Q1.5) about half of the learners provided the correct answer. All three these items required higher order cognitive ability. The worst performance is on Q1.3b, where only about 14% of the learners who answered Q1.3a correctly could also adequately explain their answer. For the two items that required lower order cognitive ability (Q1.1 and Q1.2), the majority of learners only provided partially correct answers.

6.2.2 Overall Performance on 'Systems' (Q1)

A total score for 'Systems' was derived by summing the individual item scores. The relative contribution of each item to the total score is as follows: Q1.1 = 3 points; Q1.2 = 3 points; Q1.3a&b = 2 points; Q1.4 = 1 point; Q1.5 = 1 point (Total = 10). Missing answers were scored as zero. (Except in the case of one respondent who left all the items for Q1 unanswered; hence N = 160 for the total 'Systems' scores.)

Figure 6.1 summarises the distribution of the total scores for the 'Systems' component.

Figure 6.1: Overall Performance on 'Systems' (Q1)



The mean total score for Q1 is 3.81, with both a median and mode of 5. Although the scores conform to a normal distribution, none of the learners obtained the maximum value of 10, or the second highest value of 9.

5.3.3 Overall Performance on 'Systems' (Q1) by Gender and Geographic Location

To test for significant gender differences on the total 'Systems' (Q1) scores, a t-test for independent samples was performed. The results of the t-test are shown in Table 6.2.

Table 6.2: Summary of Overall Performance on 'Systems' (Q1) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	85	3.81	1.71	-0.101	0.920
Female	69	3.84	1.82		

According to Table 6.2 boys and girls do not differ significantly with regard to their total 'Systems' scores ($p > 0.05$).

The results of the ANOVA test, which compares the total 'Systems' (Q1) scores by geographic location, are given in Table 6.3. The comparison is between 'urban' and 'rural', with the urban component broken down into three township schools and one middle class school.

Table 6.3: Summary of Overall Performance on 'Systems' (Q1) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	4.41	1.37	10.406	0.000
S2	Urban (township1)	42	3.07	1.57		
S3	Urban (township2)	35	2.91	1.69		
S4	Urban (township3)	18	4.11	1.64		
S5	Rural (middle class)	31	4.97	1.74		

According to Table 6.3 the overall performance scores on 'Systems' differ significantly by geographic location ($p < 0.05$). A Bonferroni test has shown that learners in the urban and rural middle class schools performed significantly better than learners in two township schools (S2 & S3).

6.3 Performance on 'processing' (q2)

6.3.1. Performance on 'Processing' (Q2) by Individual Item

The Question 2 items assessed the 'Processing' component of the Technology curriculum, i.e. the series of operations in manufacturing. Learners were required to sort waste products into their appropriate categories for recycling. The following question was posed:

> *Recycling is the name given to the process where used and wasted products are broken down and made into something useful. (Many people today prefer to buy a product that is recycled or environmentally friendly because it does less harm to the environment). Below is a list of some things that are often thrown away. Sort them into the correct question for recycling by ticking the correct column for each thing.*

Table 6.4 below summarises the performance per item on 'Processing' (Q2).

Table 6.4: Summary of Responses to 'Processing' (Q2) Items

	Product	N	Percent	Valid Percent
PLANT MATTER	**Potato peels**	*Missing = 9*	*Missing = 5.6*	
	Wrong	3	1.9	2.0
	Correct	149	92.5	98.0
	Total	152	94.4	100
	Lettuce leaves	*Missing = 10*	*Missing = 6.2*	
	Wrong	7	4.3	4.6
	Correct	144	89.4	95.4
	Total	151	93.8	100
METAL	**Tins**	*Missing = 6*	*Missing = 3.7*	
	Wrong	11	6.8	7.1
	Correct	144	89.4	92.9
	Total	155	96.3	100
	Cooldrink cans	*Missing = 7*	*Missing = 4.3*	
	Wrong	8	5.0	5.2
	Correct	146	90.7	94.8
	Total	154	95.7	100
PLASTIC	**Plastic bags**	*Missing = 5*	*Missing = 3.1*	
	Wrong	7	4.3	4.5
	Correct	149	92.5	95.5
	Total	156	96.9	100
	Yoghurt cups	*Missing = 7*	*Missing = 4.3*	
	Wrong	13	8.1	8.4
	Correct	141	87.6	91.6
	Total	154	95.7	100
	Egg boxes	*Missing = 7*	*Missing = 4.3*	
	Wrong	6	3.7	3.9
	Correct	148	91.9	96.1
	Total	154	95.7	100
PAPER	**Newspapers**	*Missing =4*	*Missing = 2.5*	
	Wrong	6	3.7	3.8
	Correct	151	93.8	96.2
	Total	157	97.5	100
GLASS	**Glass cooldrink bottles**	*Missing = 7*	*Missing = 4.3*	
	Wrong	8	5.0	5.2
	Correct	146	90.7	94.8
	Total	154	95.7	100

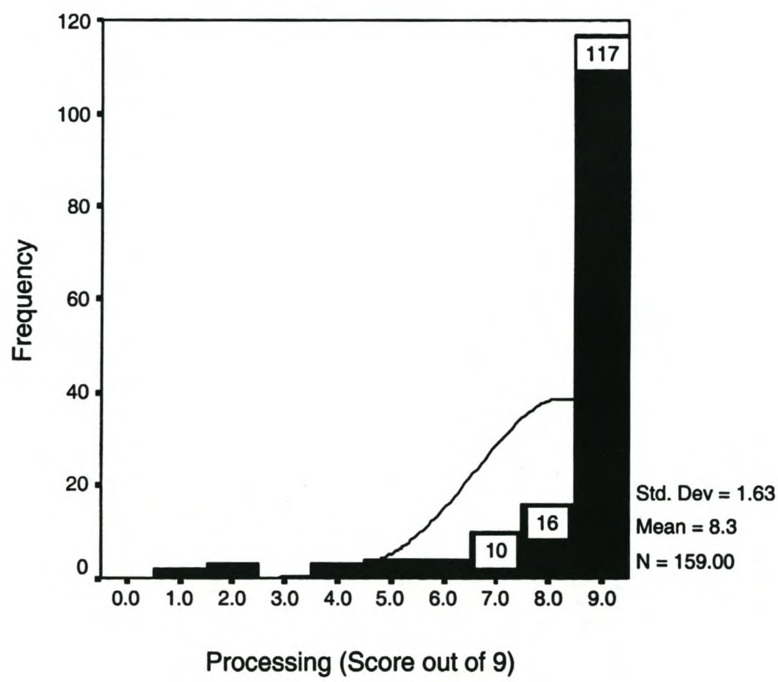
Note: In the case of 'egg boxes', two correct answers are possible - 'paper' and 'plastic'. The values in the 'Percent' column are expressed out of 161, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 152 for 'Potato peels'.

As can be seen in Table 6.4, the overwhelming majority of respondents correctly sorted the waste categories in their appropriate categories for recycling. The percentages of correct responses in the 'valid percent' column range between 91.6% and 98.0%.

6.3.2. Overall Performance on 'Processing' (Q2)

A total score out of 9 was calculated for 'Processing' (Q2) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were scored as zero. (Except for two respondents who left all the items for Q2 unanswered; hence N = 159 for the total 'Processing' scores.) The distribution of total scores is given in Figure 6.2.

Figure 6.2: Overall Performance on 'Processing' (Q2)



The mean score for 'Processing' is 8.27, which lies very close to the positive end of the scale (9). Both the median and mode are 9. The distribution is strongly skewed to the left, indicating that the question was too easy (74% of respondents got the maximum value of 9 for 'Processing').

6.3.3. Overall Performance on 'Processing' (Q2) by Gender and Geographic location

To detect a significant gender difference, the total scores on 'Processing' were subjected to a t-test for independent samples. Results are summarised in Table 6.5.

Table 6.5: Summary of Overall Performance on 'Processing' (Q2) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	84	8.48	1.31	1.628	0.106
Female	69	8.03	1.95		

According to Table 6.5 no significant gender difference is evident for 'Processing'.

The results of the F-test with geographic location as independent variable and 'Processing' as dependent variable are given in Table 6.6.

Table 6.6: Summary of Overall Performance on 'Processing' (Q2) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	8.47	1.08	30.361	0.000
S2	Urban (township1)	42	8.52	1.25		
S3	Urban (township2)	35	8.74	0.78		
S4	Urban (township3)	17	5.18	2.60		
S5	Rural (middle class)	31	8.87	0.34		

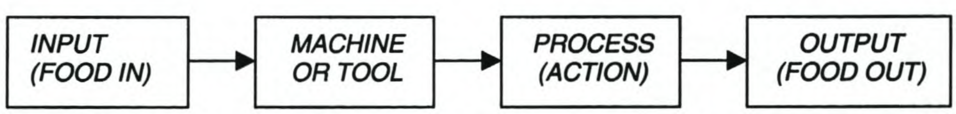
Schools in the various geographic locations have significantly different 'Processing' scores, as seen in Table 6.6 ($p < 0.05$). According to the results of the Bonferroni test, the performance of one township school (S4) is significantly poorer than that of all the other schools (the other township schools included).

6.4. Performance on 'manufacturing processes' ['manufacturing'] – (q3)

6.4.1. Performance on 'Manufacturing' (Q3) by individual Item

Question 3 items assessed the 'Manufacturing' component of the Technology curriculum. According to the curriculum, learners are required to demonstrate an understanding of the activity of processing raw materials into refined materials and products, with waste products as a by-product, in the context of bio-technology, manufacturing, agriculture or mining. Question 3 items focussed on the manufacturing process. The question was prefaced by the following:

Processing food usually involves the following steps:



Complete the table below so that the machine or tool and the process will produce the correct output.

More specifically, the learners were given four inputs together with a corresponding output (cream – butter; egg – omelette; meat – mince; and potatoes – chips). Options for the 'Machine' or 'Process' involved were also provided, from which the learners had to select the correct option(s).

Table 6.7 summarises the performance per item on 'Manufacturing' (Q3).

Table 6.7: Summary of Responses to 'Manufacturing' (Q3)

Item	Machine			Process		
	N	Percent	Valid Percent	N	Percent	Valid Percent
Cream	*Missing = 66*	*Missing = 41.0*		*Missing = 161*	*Missing = 87.6*	
Wrong	93	57.8	97.9	0	0	0
Correct	2	1.2	2.1	20	12.4	100
Total	95	59.0	100	20	12.4	100
Egg	*Missing = 4*	*Missing = 2.5*		*Missing = 2*	*Missing = 1.2*	
Wrong	83	51.5	52.9	29	18.0	18.2
Correct	74	46.0	47.1	130	80.7	81.8
Total	157	97.5	100	159	98.8	100
Meat	*Missing = 7*	*Missing = 4.3*		*Missing = 5*	*Missing = 3.1*	
Wrong	61	37.9	39.6	67	41.6	42.9
Correct	93	57.8	60.4	89	55.3	57.1
Total	154	95.7	100	156	96.9	100
Potatoes	*Missing = 8*	*Missing = 5.0*		*Missing = 4*	*Missing = 2.5*	
Wrong	41	25.5	26.8	125	77.6	79.6
Correct	112	69.6	73.2	32	19.9	20.4
Total	153	95.0	100	157	97.5	100

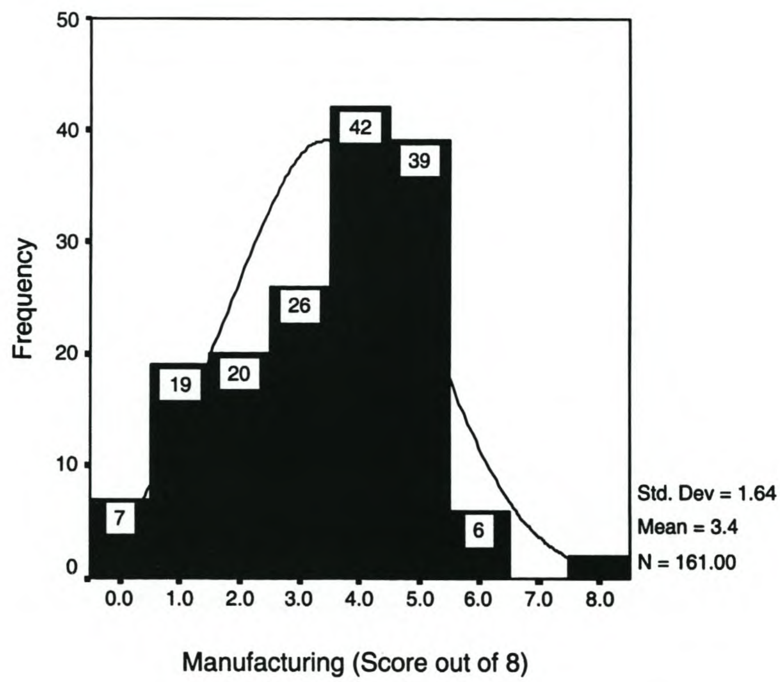
Note: The values in the 'Percent' column are expressed out of 161, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 157 for 'Egg – Machine' and 159 for 'Egg – Process'.

In Table 6.7 the manufacture of butter from cream posed the greatest challenge to the learners (both the 'machine' and 'process' involved). This is evident from the large number of missing responses and the small number of correct responses. Also, the process involved in making chips from potatoes yielded a large percentage of wrong answers (almost 80%). Only for one item did more than half of the learners indicate the correct option for both 'machine' and 'process', namely the manufacture of mince from meat. The single best performance is on the process of making omelettes from eggs (about 80% of learners gave the correct answer).

6.4.2. Overall Performance on 'Manufacturing' (Q3)

A total 'Manufacturing' score was calculated by assigning a value of 1 to a correct answer and 0 to an incorrect or missing response. These values were added up to yield a score out of 8. The distribution of the learners' total 'Manufacturing' scores is shown in Figure 6.3.

Figure 6.3: Overall Performance on 'Manufacturing'



The distribution of 'Manufacturing' scores is somewhat negatively skewed (55% of learners scored 4 or higher out of 8), with a mean of 3.43 and a median and mode of 4.

6.4.3. Overall Performance on 'Manufacturing' (Q3) by Gender and Geographic location

The total score on 'Manufacturing' was subjected to a t-test for independent samples in order to investigate gender differences. Table 6.8 contains the results.

Table 6.8: Summary of Overall Performance on 'Manufacturing' (Q3) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male Female	86 69	3.47 3.36	1.75 1.57	0.381	0.704

Boys and girls do not differ significantly in their total 'Manufacturing' scores, according to Table 6.8. The results of the F-test for geographic location appear in Table 6.9.

Table 6.9: Summary of Overall Performance on 'Manufacturing' (Q3) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	3.35	1.59	8.259	0.000
S2	Urban (township1)	42	2.79	1.55		
S3	Urban (township2)	36	4.17	1.78		
S4	Urban (township3)	18	2.33	1.41		
S5	Rural (middle class)	31	4.16	0.97		

A significant difference is evident in the performance of learners on the 'Manufacturing' subtest, as far as the geographic location of the schools are concerned ($p < 0.05$). More specifically, the mean 'Manufacturing' scores for two of the township schools (S2 and S4) are significantly lower than those of the other township school (S3) and the rural middle class school.

6.5. Performance on 'systems and control: identification of tools and equipment' ['id-t&e'] – (q4)

6.5.1. Performance on 'ID-T&E' (Q4) by Individual Item

The items on 'ID-T&E' (Q4) assessed learner ability to identify mechanical tools and equipment. Learners were required to correctly identify the picture of 6 mechanical parts presented in the table. The following question prefaced the table:

The mechanisms pictured below can increase force and decrease speed or distance travelled. Look at the diagrams below, and draw a line linking each of the diagrams (pictures) to the correct label.

Table 6.10 presents the performance of learners on individual items for Q4.

Table 6.10: Summary of Responses to 'ID-T&E' (Q4) Items

Item	N	Percent	Valid Percent
Chassis	*Missing = 9*	*Missing = 5.6*	
Wrong	66	41.0	43.4
Correct	86	53.4	56.6
Total	152	94.4	100
Chain and Sprocket	*Missing = 4*	*Missing = 2.5*	
Wrong	20	12.4	12.7
Correct	137	85.1	87.3
Total	157	97.5	100
Bevel Gear	*Missing = 9*	*Missing = 5.6*	
Wrong	73	45.3	48.0
Correct	79	49.1	52.0
Total	152	94.4	100
Wheel and Axle	*Missing = 6*	*Missing = 3.7*	
Wrong	19	11.8	12.3
Correct	136	84.5	87.7
Total	155	96.3	100
Worm and Pinion Gear	*Missing = 4*	*Missing = 2.5*	
Wrong	60	37.3	38.2
Correct	97	60.2	61.8
Total	157	97.5	100
Belt and Pulley	*Missing = 4*	*Missing = 2.5*	
Wrong	18	11.2	11.5
Correct	139	86.3	88.5
Total	157	97.5	100

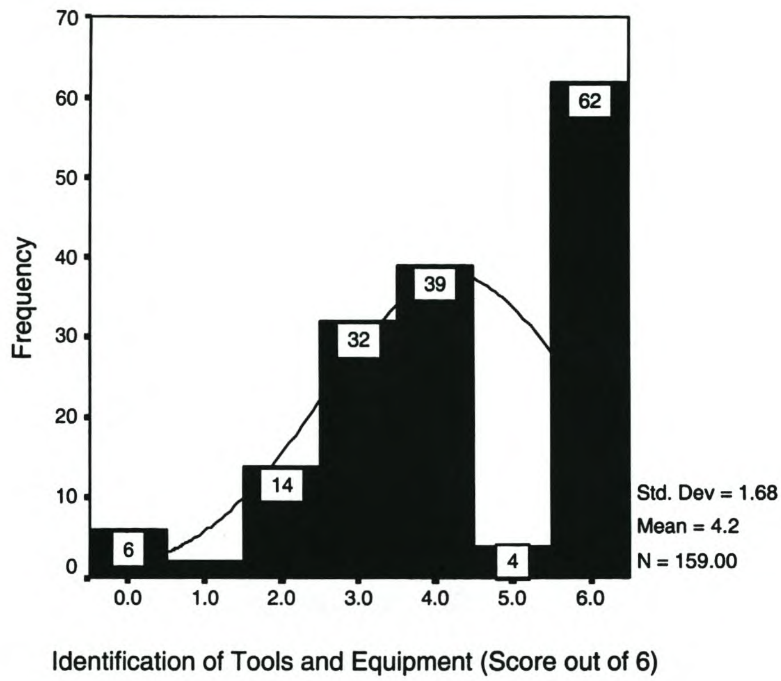
Note: The values in the 'Percent' column are expressed out of 161, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 152 for 'Chassis' and 157 for 'Chain and Sprocket'.

The responses to the 'ID-T&E' component in Table 6.10 shows that 50% or more of learners correctly identified the mechanical parts. For three of the items more than 80% of learners indicated the correct answer ('chain and sprocket', 'wheel and axle' and 'belt and pulley').

6.5.2. Overall Performance on 'ID-T&E' (Q4)

A total score out of 6 was calculated for 'ID-T&E' (Q4) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were also scored as zero. (Except for 2 respondents who left all items for Q4 unanswered; hence N = 159.) The distribution of the learners' total scores for 'ID-T&E' appears in Figure 6.4.

Figure 6.4: Overall performance on 'ID-T&E'



The mean of the distribution is 4.24, with a median and mode of 4 and 6, respectively. The distribution is negatively skewed: more learners scored on the higher end of the scale than on the lower end of the scale. Also, the distribution covers the full range of possible scores.

6.5.3. Overall Performance on 'ID-T&E' (Q4) by Gender and Geographic location

The results of the t-test, to investigate whether boys and girls differ significantly with regard to their total 'ID-T&E' scores, are given in Table 6.11.

Table 6.11: Summary of Overall Performance on 'ID-T&E' (Q4) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	85	4.45	1.58	1.810	0.072
Female	68	3.96	1.77		

As can be seen in Table 6.11, the gender difference on the overall 'ID-T&E' scores is not statistically significant ($p > 0.05$).

The results of the F-test with geographic location as independent variable and the total 'ID-T&E' scores as dependent variable are given in Table 6.12.

Table 6.12: Summary of Overall Performance on 'ID-T&E' (Q4) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	4.59	1.54	23.828	0.000
S2	Urban (township1)	41	4.12	1.31		
S3	Urban (township2)	35	4.11	1.53		
S4	Urban (township3)	18	1.78	1.31		
S5	Rural (middle class)	31	5.58	0.81		

A significant difference was found in the overall 'ID-TEC' performance of schools in the various geographic locations. According to a Bonferroni test, all the means differ significantly from one another, with the exception of the differences in the means of the urban middle class and two of the township schools (S2 and S3). The highest mean score was obtained by learners in the rural middle class school.

6.6. Performance on systems and control: use of tools and equipment– ['use-t&e'] – (q5)

6.6.1. Performance on 'USE-T&E' (Q5) by Individual Item

The items on 'USE-T&E' (Q5) assessed learners' understanding of the operating principles of simple mechanical systems. Four diagrams were displayed (A to D), three with two wheels and one with three wheels. Each diagram had an arrow indicating the direction of movement of at least one wheel. The learners were presented with the following instruction:

> *Look at the diagrams below. In each case, the left-hand wheel is rotating (turning) in a clockwise direction (to the right). Draw an arrow to indicate the direction the right hand wheel is turning. [In D, indicate (show) the direction that the other two wheels are turning.]*

An additional item follows the set of diagrams, which reads:

> *In two of the diagrams, the direction of movement changes (*learners were asked to indicate which diagrams*). In your own words, explain how this happens.*

Table 6.13 illustrates the performance per item on 'USE-T&E' (Q5).

Table 6.13: Summary of Responses to 'USE-T&E' (Q5) Items

	Item	N	Percent	Valid Percent
Direction that wheels are turning	**A: Wheels and Band (uncrossed)**	*Missing = 11*	*Missing = 6.8*	
	Wrong	8	5.0	5.3
	Correct	142	88.2	94.7
	Total	150	93.2	100
	B: Wheels and Band (crossed)	*Missing = 9*	*Missing = 5.6*	
	Wrong	19	11.8	12.5
	Correct	133	82.6	87.5
	Total	152	94.4	100
	C: Two wheels with grooves	*Missing = 6*	*Missing = 3.7*	
	Wrong	41	25.5	26.5
	Correct	114	70.8	73.5
	Total	155	96.3	100
	D1: Three wheels with grooves (Middle wheel)	*Missing = 52*	*Missing = 32.3*	
	Wrong	22	13.7	20.2
	Correct	87	54.0	79.8
	Total	109	67.7	100
	D2: Three wheels with grooves (Last wheel)	*Missing = 6*	*Missing = 3.7*	
	Wrong	31	19.3	20.0
	Correct	124	77.0	80.0
	Total	155	96.3	100
Additional	**In which two diagrams do the direction of movement change?**	*Missing = 16*	*Missing = 9.9*	
	Wrong	7	4.3	4.8
	1 Correct	67	41.6	46.2
	2 Correct	71	44.1	49.0
	Total	145	90.1	100
	Why do the direction of movement change?	*Missing = 12*	*Missing = 7.5*	
	Wrong	70	43.5	47.0
	1 Correct	59	36.6	39.6
	2 Correct	20	12.4	13.4
	Total	149	92.5	100

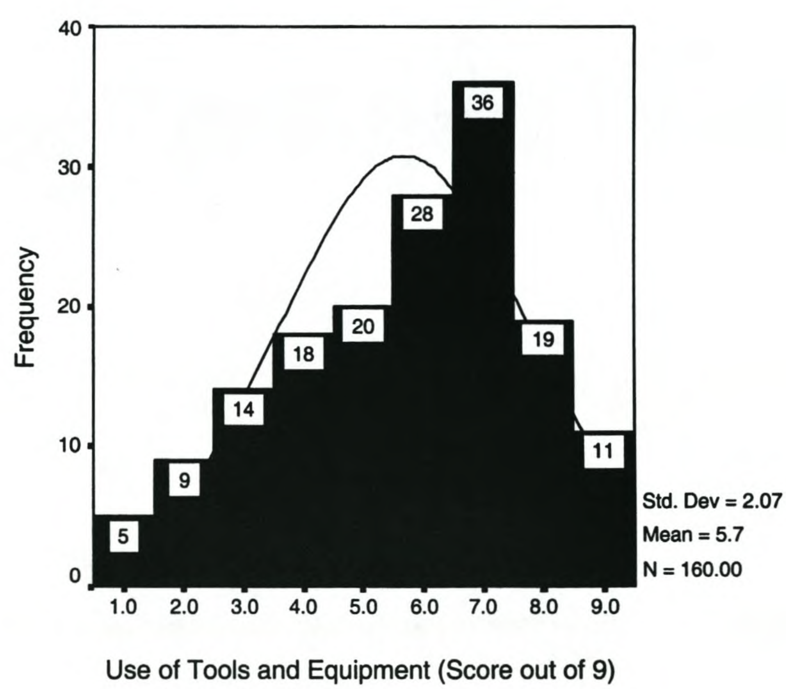
Note: The values in the 'Percent' column are expressed out of 161, and the values in the 'Valid percent' column out of the valid totals for each item, e.g. 150 for 'Wheels and band (uncrossed)'.

About 32% of learners did not indicate the direction in which the middle wheel in diagram D is changing. However, learners demonstrated no significant problems to indicate the correct directions of the wheels, as about 70%+ of learners provided the correct answer to each diagram. The learners primarily experienced difficulty with the additional items, especially the last item that required the respondents to state a reason for their answer.

6.6.2. Overall Performance on 'USE-T&E' (Q5)

A total 'USE-T&E' score was derived by summing the learner's responses to the individual items. The relative contribution of each item to the total score was as follows: A to D2 = 1 point each and the two additional items = 2 points each (Total = 9) A missing answer was also calculated as zero. (Except for one respondents who left all the items unanswered; hence N = 160.). Figure 6.5 summarises the distribution of the total scores for the 'USE-T&E' component.

Figure 6.5: Overall Performance on 'USE-T&E' (Q5)



The mean of the distribution of total 'USE-T&E' scores is 5.68, with a median of 6 and a mode of 7. The learners utilised the full range of the scale. Also, scores tend to cluster at the upper end of the scale (almost 60% of learners obtained a score of 5 or higher).

6.6.3. Overall performance on 'USE-T&E' (Q5) by gender and geographic location

Table 6.14 contains the result of the t-test that investigated gender differences.

Table 6.14: Summary of Overall Performance on 'USE-T&E' (Q5) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	85	6.26	1.90	4.048	0.000
Female	69	4.96	2.08		

A higher total 'USE-T&E' score was obtained by boys (6.26) than by girls (4.96), and the difference is statistically significant ($p < 0.05$). A comparison was also made of the total 'USE-T&E' scores by the geographic location of the schools. The results of the F-test are reported in Table 6.15.

Table 6.15: Summary of Overall Performance on 'USE-T&E' (Q5) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	6.21	1.63	16.221	0.000
S2	Urban (township1)	42	5.19	1.85		
S3	Urban (township2)	35	5.80	2.00		
S4	Urban (township3)	18	3.11	1.68		
S5	Rural (middle class)	31	7.10	1.51		

According to Table 6.15 the total 'USE-T&E' scores of the learners differ significantly by the geographic location of the schools. More specifically, the mean scores in the three township schools are significantly lower than those in the rural middle class school. Also, the third township school (S4) scored significantly lower on the test of 'USE-T&E' than the urban middle class school and the other two townships.

6.7. Performance on 'Electrical and electronic systems' ['Electrical

systems'] – (q6)

6.7.1. Performance on 'Electrical systems' (q6) by individual item

The items for Question 6 assess learner understandings of 'Electrical Systems'. Learners were presented with two diagrams - one connected in series and the other in parallel. The question read as follows:

> *In each of these circuits pictured below, the light will glow when the switch closes the circuit.*

A series of questions relating to the circuits were then posed. Table 6.16 illustrates the performance per item on 'Electrical Systems'.

Table 6.16: Summary of Responses to 'Electrical Systems' (Q6) Items

Item	N	Percent	Valid Percent
6.1: What is the source of energy that allows the light to glow?	*Missing = 5*	*Missing = 3.1*	
Wrong Correct Total	49 107 156	30.4 66.5 96.9	31.4 68.6 100
6.2: In which circuit will the light glow the brightest?	*Missing = 4*	*Missing = 2.5*	
Wrong Correct Total	71 86 157	44.1 53.4 97.5	45.2 54.8 100
6.3: Why	*Missing = 5*	*Missing = 5.8*	
Wrong Correct Total	46 35 81	53.5 40.7 94.2	56.8 43.2 100
6.4: What will happen if we break the circuit at X?	*Missing = 4*	*Missing = 2.5*	
Wrong Correct Total	39 118 157	24.2 73.3 97.5	24.8 75.2 100
6.5: What will happen if we break the circuit at Y?	*Missing = 14*	*Missing = 8.7*	
Wrong Correct Total	73 74 147	45.3 46.0 91.3	49.7 50.3 100

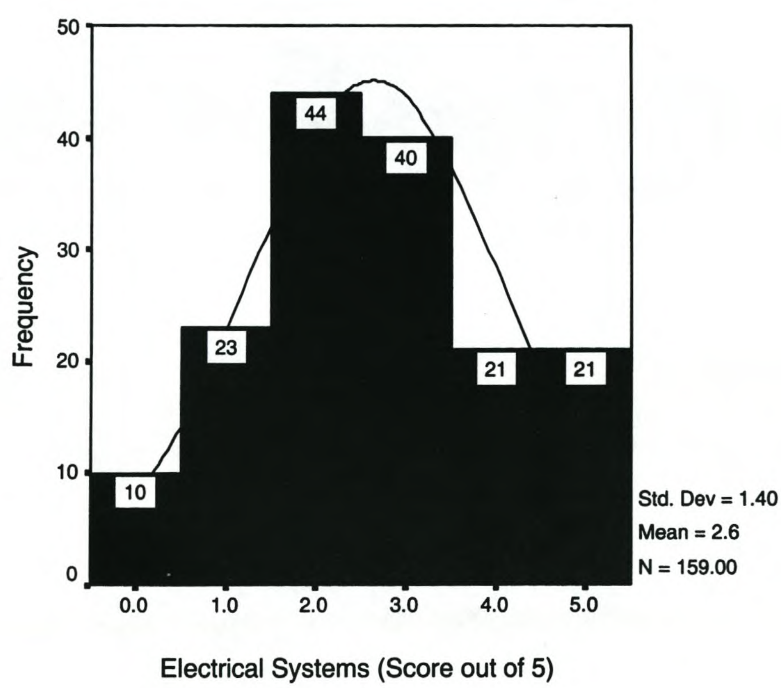
Note: The values in the 'Percent' column are expressed out of 161 (with the exception of Q6.3, which is based on the number of learners who answered Q6.2 correctly, namely 86). The values in the 'Valid percent' column were calculated by using the valid totals for each item, e.g. 156 for Q6.1 and 157 for Q6.2.

Overall, the results in Table 6.16 show a moderate performance on the 'Electrical Systems' component. For two of the items (Q6.1 and Q6.4) at least two thirds of learners stated the correct response. The worst performance is on the item that requested the learners to motivate an answer (Q6.3).

6.7.2. Overall Performance on 'Electrical Systems' (Q6)

A total score out of 5 was determined for 'Electrical Systems' by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were scored as zero. (Two respondents left all the items for Q6 unanswered; hence N = 159.) The distribution on total scores for 'Electrical Systems' is represented in Figure 6.6.

Figure 6.6: Overall Performance on 'Electrical Systems' (Q6)



The mean total score for 'Electrical Systems' is 2.64, with a median of 3 and a mode of 2. The distribution is slightly positively skewed, as 61% of learners had a score of 2 or less.

6.7.3. Overall Performance on 'Electrical Systems' (Q6) by Gender and Geographic location

To investigate significant gender differences, the total scores on 'Electrical Systems' were subjected to a t-test for independent samples. Results are summarised in Table 6.17.

Table 6.17: Summary of Overall Performance on 'Electrical Systems' (Q6) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	84	2.67	1.37	0.506	0.613
Female	69	2.55	1.45		

No significant gender difference is evident in Table 6.17 ($p > 0.05$). Table 6.18 gives the results of the F-test with geographic location as independent variable and the total 'Electrical Systems' scores as dependent variable.

Table 6.18: Summary of Overall Performance on 'Electrical Systems' (Q6) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	34	3.15	1.23	14.732	0.000
S2	Urban (township1)	42	2.55	1.43		
S3	Urban (township2)	35	2.63	1.00		
S4	Urban (township3)	18	0.78	0.73		
S5	Rural (middle class)	30	3.33	1.27		

The significant difference in Table 6.18 is primarily because of a lower mean score on 'Electrical Systems' for one of the township schools (S4), as compared to the scores of learners in the other schools.

6.8. Performance on structures (q7)

6.8.1. Performance on Structures (Q7) by Individual Item

Question 7 Items assess learner understanding of 'Structures'. The first two of six items (Q7.1 and Q7.2) assessed learner understanding of the effect of loads on the stability of structures. The latter four items (Q7.3 to Q7.6) assessed their understanding of the characteristics of basic structural components. Table 6.19 illustrates the performance per item on 'Structures'.

Table 6.19: Summary of Responses to 'Structures' (Q7) Items

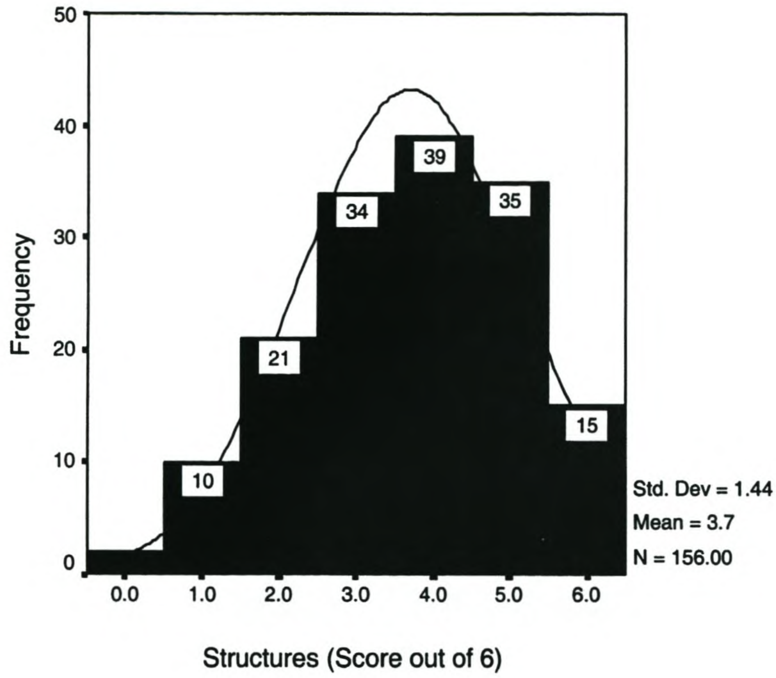
Item	N	Percent	Valid Percent
7.1: Which beam is most likely to sag and bend if the weight of the load is increased? Circle A or B	*Missing = 9*	*Missing = 5.6*	
Wrong	26	16.1	17.1
Correct	126	78.3	82.9
Total	152	94.4	100
7.2: Why?	*Missing = 5*	*Missing = 4.0*	
Wrong	41	32.5	33.9
Correct	80	63.5	66.1
Total	121	96.0	100
7.3: Which (beam) is the strongest? Circle C, D or E	*Missing = 11*	*Missing = 6.8*	
Wrong	23	14.3	15.3
Correct	127	78.9	84.7
Total	150	93.2	100
7.4: Why?	*Missing = 9*	*Missing = 7.1*	
Wrong	68	53.5	57.6
Correct	50	39.4	42.4
Total	118	92.9	100
7.5: Which (beam) is the weakest? Circle C, D or E	*Missing = 12*	*Missing = 7.5*	
Wrong	21	13.0	14.1
Correct	128	79.5	85.9
Total	149	92.5	100
7.6: Why?	*Missing = 8*	*Missing = 6.3*	
Wrong	58	45.3	48.3
Correct	62	48.4	51.7
Total	120	93.8	100

Note: The values in the 'Percent' column are expressed out of 161, with the exception of Q7.2, Q7.4 and Q7.6, which are based on the number of learners who answered the preceding items correctly. Although more than 80% of learners correctly circled an option for Q7.1, Q7.3 and Q7.5, substantially smaller percentages could adequately motivate their decision.

6.8.2. Overall Performance on Structures (Q7)

A total score out of 6 was calculated for 'Structures' (Q7) by summing the individual item scores (1 = correct; 0 = wrong). Missing answers were also scored as zero. (Except for 5 respondents who left all items for Q7 unanswered; hence N = 156.). The distribution of the learners' total scores for 'Structures' appears in Figure 6.7.

Figure 6.7: Overall Performance on 'Structures' (Q7)



The mean total score for 'Structures' is 3.69, with a median and mode of 4. The scores are negatively skewed, implying a clustering of scores at the higher end of the scale (52% of learners scored 4 or higher).

6.8.3. Overall Performance on 'Structures' (Q7) by Gender and Geographic Location

A t-test was done to compare the mean 'Structures' scores of boys and girls for a statistically significant difference.

Table 6.20: Summary of Overall Performance on 'Structures' (Q7) by Gender

Gender	N	Mean	Std. Deviation	t	p
Male	81	3.58	1.47	-1.178	0.241
Female	69	3.86	1.36		

According to Table 6.20 boys and girls do not differ significantly regarding their total 'Structure' scores (p > 0.05). The comparison for geographic location is given in Table 6.21.

Table 6.21: Summary of Overall Performance on Structures (Q7) by Geographic Location

School	Location	N	Mean	Std. Deviation	F	p
S1	Urban (middle class)	33	3.73	1.46	4.456	0.002
S2	Urban (township1)	41	3.88	1.44		
S3	Urban (township2)	34	3.74	1.42		
S4	Urban (township3)	18	2.44	1.20		
S5	Rural (middle class)	30	4.07	1.23		

The significant difference in Table 6.21 is primarily because learners in one of the township schools (S4) obtained a significantly lower mean on the 'Structures' component than learners in the other schools.

6.8. Summary of performance on all questions

Total scores were also compared for the seven questions. Table 6.22 gives the comparison, with scores converted into percentages. The three township schools have been grouped together in order to simplify the comparison. However, this does not imply homogeneity of scores for the township schools, as recalled from the results of Tables 6.6, 6.9, 6.12, 6.18 and 6.21 (where learner performance in the one township school differ significantly from that in the other township schools).

Table 6.22: Mean Total Scores (out of 100) by Gender and Geographic Location

Comparison	Systems (Q1)	Processing (Q2)	Manufacturing (Q3)	ID-T&E (Q4)	USE-T&E (Q5)	Electrical Systems (Q6)	Structures (Q7)
Gender							
Male	38.1	94.2	43.3	74.1	69.5	53.3	59.7
Female	38.4	89.2	42.0	65.9	55.1	51.0	64.3
Geographic location							
Urban (middle class)	44.1	94.1	41.9	76.5	69.0	62.9	62.1
Township	32.1	88.9	40.2	61.2	55.8	44.8	59.1
Rural (middle class)	49.7	98.6	52.0	93.0	78.9	66.7	67.8
Total	38.1	91.9	42.9	70.6	63.1	52.8	61.4

From Table 6.22 it is evident that:

All groups have mean performance scores greater than 50% for 'Processing', 'ID-T&E', 'USE-T&E' and 'Structures'. All groups have mean performance scores of less than 50% for 'Systems'. The rural, middle class learners have the highest mean on all questions. The urban township learners have the lowest mean on all questions. Overall (for all groups) the best performance is in 'Processing' and the worst in 'Systems'. These observations are supplemented by the outcome of the tests of statistical significance, summarised as follows:

Boys performed significantly better than girls on 'USE-T&E'. Mean performances on all the questions differ significantly by geographic location, in the following direction:

- 'Systems' : Urban middle class > Urban township1&2
  Rural middle class > Urban township1&2
- 'Processing' : Urban township 3 < Rest
- 'Manufacturing' : Rural middle class > Urban townships 1&3
  Urban township 2 > Urban townships 1&3
- 'ID-T&E' : Rural middle class > Rest
  Urban township 3 < Rest
- 'USE-T&E' : Rural middle class > Urban townships 1,2 & 3
  Urban middle class > Urban township 3
  Urban townships 1&2 > Urban township 3
- 'Electrical Systems' : Rest > Urban township 3
- 'Structures' : Rest > Urban township 3

6.10. Discussion

For the Intermediate Phase, geographic location appeared to be a significant correlate of differences in performance on the PUT. Gender, on the other hand, did not appear to play any significant role in the determination of differences in test scores. On only one question ('USE-T&E'), did boys and girls differ significantly in their performance.

A low level of difficulty was evidently experienced with four of the questions as all of the groups were able to achieve a score above the 50% mark. The question on 'Systems' did however present learners with some problems. For this question, none of the groups were able to score higher than 50%. Thus, even though differences between the urban and rural middle class and urban township schools 1 and 2, was significant in favour of the former two schools, the better-performing schools are still performing at a level which may be considered insufficient.

The finding that the rural middle class performed significantly higher on all items than all other groups, points to the importance of socio-economic background as a further indicator of access to relevant technological knowledge. Several possibilities exist. It may be that despite their rural location, learners still have access to modern, advanced technology because of the relatively close proximity of this school to the nearest urban centre. It may also be that as this is a boarding school, and learners would thus not be indigenous to the area, that their knowledge of technology is related to the urban centres from which they come rather than to the rural area in which they attend school.

The finding that all three urban township schools have the lowest mean on all questions also raises some interesting issues. Although one should be cautious about generalising, township schools are notorious for the lack of a culture of teaching and learning, lack of or insecurity of infrastructure and teaching and learning resources, and lack of a trained cadre of staff, particularly with the relevant experience and subject-specific training in Technology. The confluence of these factors could explain these low levels of attainment on the PUT. However, a further point needs to be made. The state of affairs in township schools constitutes a general condition, which may be related to generally poor learner performance at these schools. It does not fully explain the performance of learners on the PUT, as the minimum requirements for effective teaching and learning in technology (which may require different resources form the traditional subjects) within the South African schooling context have not been determined. Thus, the lack of information on school environments and learner backgrounds for schools in this sample, limits the conclusiveness of any interpretation based on school-level variables.

6.11. Conclusion

To conclude, there appears to be a significant difference in the performance of learners by geographic location on all items, but only a low level of significance (on just one question) for gender at the Senior Phase level. The greatest differences were observed between the rural middle class and other schools. The discussion above also suggests the need for further interrogation of the concept of access to relevant technological knowledge, to ensure findings are interpreted in light of all relevant variables. Chapter 7 compares the performance of learners across the three phases.

CHAPTER 7
A COMPARISON BETWEEN PHASES

7.1. Introduction

This chapter compares the performance of learners in the three phases with regard to their knowledge and understanding of Technology, as measured by the PUT instruments. The comparison is made possible because learners in the Intermediate and Senior Phases completed identical instruments. Two questions in the Intermediate/ Senior Phase PUT instrument were also included in the instrument for Foundation Phase Learners. A comparison will first be made for each question separately, followed by a comparison of the questions in juxtaposition. Only total scores will be considered.

7.2. Comparison between phases for each question

As mentioned before, the Foundation Phase PUT consisted of four questions and the Intermediate/Senior PUT of seven questions, with two questions overlapping ('Systems' and 'Processing'). Table 7.1 compares the performance of the three phases on these two questions.

Table 7.1: Summary of Overall Performance on 'Systems' (Q1) and 'Processing' by Phase

Phase	N	Mean	Std. Deviation	F	p
Systems					
Foundation	126	3.51	1.71	7.987	0.000
Intermediate	181	4.35	2.07		
Senior	160	3.81	1.78		
Processing					
Foundation	126	4.76	2.62	88.139	0.000
Intermediate	181	7.15	2.42		
Senior	159	8.27	1.63		

The score on 'Systems' in Table 7.1 is out of a maximum of 10. Although the mean performance for each phase is below the midpoint value of 5 (scale ranges from 0 to 10), the means differ significantly ($p < 0.05$). Intermediate Phase learners obtained a significantly higher mean than learners in the Foundation and Senior Phases. (Readers interested in a comparison of the individual items comprising 'Systems', are referred to Tables 4.1, 5.1 and 6.1.) The mean performances of the Foundation and Senior Phase learners, however, do not differ significantly.

The score for 'Processing' is out of 9, meaning that the Intermediate and particularly the Senior Phase learners obtained above average scores on this question. The means of the scores for each phase differ significantly (every mean is significantly different from the other) and in the expected direction: Senior Phase learners have the highest mean and Foundation Phase learners the lowest. The results of the between phases comparison for the remaining questions in the Intermediate/Senior Phase PUT are summarised in Table 7.2.

Table 7.2: Summary of Overall Performance on 'Manufacturing' (Q3), 'ID-T&E' (Q4), 'USE-T&E' (Q5), 'Electrical Systems' (Q6) and 'Structures' (Q7) by Phase

Phase	N	Mean	Std. Deviation	t	p
Manufacturing					
Intermediate	182	2.73	1.77	-3.797	0.000
Senior	161	3.43	1.64		
ID-T&E					
Intermediate	176	3.54	1.67	-3.815	0.000
Senior	159	4.24	1.68		
USE-T&E					
Intermediate	173	4.20	2.34	-6.064	0.000
Senior	160	5.68	2.07		
Electrical Systems					
Intermediate	180	1.71	1.24	-6.474	0.000
Senior	159	2.64	1.40		
Structures					
Intermediate	178	3.20	1.52	-2.973	0.003
Senior	156	3.69	1.44		

The performances on all questions in Table 7.2 are as expected: Senior Phase learners performed better than Intermediate Phase learners. For each question the difference in mean scores is statistically significant.

7.3. Phase comparisons of questions in juxtaposition

Because the questions have different maximum values, performances on the questions could only be compared for the phases once the scores had been converted into percentages. Table 7.3 shows the mean performance by each phase on the various questions (scores calculated out of 100). The questions are juxtaposed.

Table 7.3: Mean Total Scores on All Questions (out of 100) by Phase

Phase	Systems (Q1)	Processing (Q2)	M&E (Q3)	M&C (Q4)	Manufacturing (Q3)	ID-T&E (Q4)	USE-T&E (Q5)	Electrical Systems (Q6)	Structures (Q7)
Foundation	35.1	52.9	57.8	62.2	--	--	--	--	--
Intermediate	43.5	79.5	--	--	34.1	59.0	46.7	34.2	53.4
Senior	38.1	91.9	--	--	42.9	70.6	63.1	52.8	61.4

From Table 7.3 it is evident that:

- On average, all three phases failed the 'Systems' component whereas both the Intermediate and Senior Phases failed the 'Manufacturing' component (averages are below 50%, which can be regarded as a pass mark)
- Intermediate Phase learners have (on three questions) a mean performance score of at least 50% obtained, whereas Senior Phase learners obtained (on five questions) a mean score of 50% or higher.

Table 7.4 is another way to compare the performances of the phases. The values in the table represent the percentages of learners who passed each question (i.e. the percentages of learners who scored 50% or higher on each question).

Table 7.4: Percentage of Learners in Each Phase Scoring 50% and Higher

Phase	Systems (Q1)	Processing (Q2)	M&E (Q3)	M&C (Q4)	Manufacturing (Q3)	ID-T&E (Q4)	USE-T&E (Q5)	Electrical Systems (Q6)	Structures (Q7)
Foundation	27	55	64	72	--	--	--	--	--
Intermediate	46	83	--	--	36	74	49	28	65
Senior	35	95	--	--	55	86	71	52	79

From an inspection of Table 7.4 , the following is evident. Eighty percent or more of the learners in the Senior Phase passed the questions on 'Processing', 'ID-T&E', and 'Structures'. Leraners in the Intermediate Phase passed only one question ('Processing') with scores above 80%. Significantly lower percentages of learners (less than 30%) passed the 'Systems' question for the Foundation Phase and the 'Electrical systems' question for the Intermediate Phase. 'Electrical systems' and 'USE-T&E' are the best discriminators in terms of the performance of Intermediate and Senior Phase learners – the questions represent a 24% and 22% difference in pass rate, respectively (52 - 28 = 24 and 71 – 49 = 22).

7.4. Discussion and conclusion

A comparison of results across the phases suggests that learner knowledge of technology increases by developmental level, as indicated by the phase. This is evidenced by the fact that learners from the Senior phase consistently out-performed learners from the other two phases, by obtaining a pass mark on more questions than their younger counterparts. This is however an expected finding, as technological literacy is a subset of general achievement, and so should increase with an increase in developmental level. To conclude, the main finding for this section has been summarised above. The following chapter (Chapter 8) summarises the main findings and draws some summary conclusions.

CHAPTER 8
CONCLUSION

8.1. Introduction

In this study, technological literacy has been described as a multi-dimensional construct comprised of an amalgam of cognitive, psychomotor and affective aspects. Herein learner knowledge and understanding of technology, the cognitive dimension of technological literacy, has been assessed, through a standardised paper-and-pencil assessment, the Pupil's Understanding of Technology (PUT) test. In concluding this study, this chapter will discuss the main substantive findings with regard to learners' technological knowledge, and re-iterate key methodological points.

The study attempted to measure the effect of two variables - geographic location and gender, on learner knowledge and understanding of technology. The main substantive findings to emerge are firstly that geographic location is a significant correlate of performance in specific content areas of technology. This was found to be the case for most content areas on the PUT, and applies equally to the Foundation, Intermediate and Senior Phases. Secondly, gender appears to be less significant in determining learner knowledge of technology on most questions. This is also true for all phases. Furthermore, the level of knowledge of technology appears to correspond with phase or developmental level, thus supporting the conception of technological knowledge as a subset of general achievement. These findings merit further discussion.

At the Foundation phase, geographic location was a key determinant of differences in learner performance on the PUT for the majority of questions (three out of the four questions). The significantly higher scores achieved by rural learners (compared to both their urban and peri-urban counterparts) on two of three questions for which significant differences were reported ('Systems' and 'M&C'), was attributed to differences in their respective technological environments. However, the range of performance, even for the better-performing rural learners is still below the 'pass mark' of 50% for one of the questions, 'Systems'. Thus, the performance of all Foundation phase learners (including rural learners) on these aspects of technological conceptual knowledge is inadequate, and geographic location, whilst offering rural learners a significant advantage, in all probability co-varies with other important variables in determining learner performance on these aspects Technology. On the 'Processing' aspect of Technology, on which urban learners scored a pass mark (50%), but urban and peri-urban learners failed, the significant difference in urban performance vs other schools does not exclude the likelihood of covariance with other variables. However, the role of geographic location may be greater in determining learner knowledge and understanding of technology on this aspect at the Foundation phase level. This reaffirms the description of technology as 'socio-culturally located', and hence the need for an analysis of additional variables relevant to technological learning.

For Intermediate phase learners, the most pertinent overall finding is that geographic location was significant for all questions, whilst gender differences were significant for only one question, 'Processing'. The findings on the effect of geographic location on PUT scores suggests that urban middle class learners have a distinct advantage over other learners, having achieved the highest mean scores overall on all questions, and significantly higher scores on two of the seven questions. However, equally important is the difference in performance by socio-economic category ('middle class', 'poor white', 'township') *within* the different geographic locations ('urban', 'rural' and 'peri-urban'). Significant differences were found between the poorer socio-economic categories – the urban poor white, and the urban township school in favour of the poor white. Thus, whilst a difference between the middle class and other (lower) class learners is an expected finding, the big gap between learners of roughly the same socio-economic category is somewhat unexpected. This finding suggests the need for a consideration of other socio-cultural determinants of technological knowledge in addition to geographic location and socio-economic position.

At the Senior phase level, geographic location appears to play a greater role in determining PUT scores than did gender. There was a significant difference in performance between boys and girls on only one question. However, for one question, 'Systems', none of the schools were able to achieve a pass mark. Thus, there may a be a relative advantage for middle class schools (both rural and urban) with regard to this aspect, which suggests that socio-economic position of learners may play a greater role in determining PUT performance on this question than geographic location alone. However, with regard to overall PUT performance, it would appear that rural location combined with a middle class socio-economic position would increase the attainment of learners. The limitations in this regard - their strong linkages with urban centres and with modern technological environments, etc. have been detailed in Chapter 6 and will not be recounted here.

Not suprising, the comparison of results across the phases suggests that learner knowledge and understanding of technology increases with developmental level. Lewis and Gagel (1992) state that levels of knowledge correlate with levels of literacy.

Senior phase learners not only consistently outperformed Intermediate and Foundation phase learners on questions that over-lapped, but were also able to achieve a pass mark on more questions than the other two phases. This finding is not surprising. However, the literature on technological literacy suggests that due to the context-dependent nature of technological conceptual knowledge, it would be a mistake to refer to a learner as having achieved technological literacy. Part of this limitation derives from the structure of technological knowledge. The literature describes technology and technological activity, (including curriculum activity) as lacking a clearly generalisable, representative structure. Thus, claims about knowledge in specific aspects of technology too, cannot be generalised to the learner. Despite the correlation of knowledge with literacy (Lewis and Gagel, 1992), a learner may thus only be described as more or less knowledgeable in some aspect of technology. When comparing phases, it is apparent that learners are knowledgeable about different aspects at different levels. A 50% pass mark has been used for convenience to make this determination.

In the discussion of the substantive findings above, the main aspects reported on are differences overall and on individual questions per category of the PUT, by the two main variables – gender and geographic location. The discussion has also reported on the adequacy of conceptual knowledge on any one aspect, whether or not significant differences have been noted. Essentially, this discussion has focussed on the conceptual aspects of technological knowledge, the content. What is missing is a discussion of how attainment in the conceptual aspect of technological knowledge relates to it's complement, procedural knowledge. Technological knowledge acquires form and purpose in specific human activity and the the character of technological knowledge is defined by its use. This description means that theoretically, it is not accurate to speak of technological knowledge in terms of the conceptual aspect outside of its use. This is because isolated from activity and removed from the implementing context, much of technological knowledge loses its meaning and identity (Paravil, 1991). Thus, learner conceptual knowledge, even if described in terms of specific content knowledge, is not representative of learner competence in technology because the technology curriculum has a strong emphasis on procedural aspects. The PUT assessment, in exclusively assessing learner knowledge, thus represents an under-representation of the construct of technological literacy. This is at odds with research which has begun to show that procedural knowledge is used in combination with conceptual knowledge (understanding relationships among relevant concepts) and strategic knowledge (planning what to do next) to solve practical problems (Levinson, Murphy & McCormick, 1997; McCormick, 1996).

Linn et. al. (1991) suggest that all forms of assessment, including authentic assessment (e.g. performance assessment), are somewhat disconnected from the world, and that a range of assessment practices are better suited to assess learning in an activity-based subject like technology. Furthermore, a range of assessment practices would be better suited to develop technologically competent learners i.e. learners with both knowledge of and competence in technology. It would allow for group-based activity, for creative problem solving and for the accommodation of different learning styles. The nature of standardised paper-and pencil assessment formats like the PUT, however, rules out the possibility of addressing these aspects of learning in technology.

The substantive findings which have been reported here, highlighted the need for more detailed information on school-level and individual learner variables (including 'experiential' and 'attitudinal' factors (Fisher, 1990) and for an interrogation of the monolithic categories 'geographic location' and 'socio-economic category'. This is also supported by socio-cultural theories of learning, in particular, situated learning theory, according to which learning is located in both a situational and socio-cultural context. As technological knowledge is the sum of in-schools and out of school experiences – peer interaction, parental occupation, exposure to relevant technological environments, this information is key in determining learner performance in technology. In addition, with regard to in-school learning, various factors may be determinants of the delivery of the curriculum, and ultimately of learning outcomes. Indeed technological literacy has been described as an outcome of the curriculum.

A further limitation of the study is that the relatively small sample size did not allow for a statistical comparison of boys vs girls performance within and across geographic locations. This analysis is key in determining the curriculum effects of technology, and to what extent the technology curriculum has addressed gender redress in technological fields of learning. If, as has been argued above, geographic location and socio-economic status are so significant in determining differences in learner knowledge and understanding of technology, to what extent do girls within particular locations continue to perform according to the stereotype of girls i.e. generally achieving lower scores on cognitive and affective aspects of technological learning.

8.2. Conclusion

To conclude therefore, the main limitations to an assessment of learner knowledge and understanding of technology using the PUT instrument relates to the nature of technological knowledge, and the understanding that technological literacy is a complex, multi-dimensional and activity-based subject. The study highlights the need for an interrogation of the monolithic categories of 'geographic location' and 'socio-economic' category. Most useful would be a factor analytical study of the relative contribution of technology relevant variables. Furthermore, given the limitations of a paper-and-pencil test, the study calls for greater attention in developing summative assessment with a high(er) degree of authenticity with regard to the technology learning context. This would of course require research into the validity aspects of performance assessment, the primary limitation with regard to this type of assessment.

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APPENDICES

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1. FOUNDATION PHASE PUT INSTRUMENT

   INTERMEDIATE / SENIOR PHASE PUT INSTRUMENT

2. CONTROL SHEET FOR FACILITATORS

3. LETTER REQUESTING CONSENT FROM SCHOOLS

4. FAX TO SCHOOLS WITH INSTRUCTIONS

FOUNDATION PHASE
LEARNER'S SCHEDULE

SURNAME, NAME:

AGE:

GENDER:

GRADE:

TECHNOLOGY TEACHER NAME:

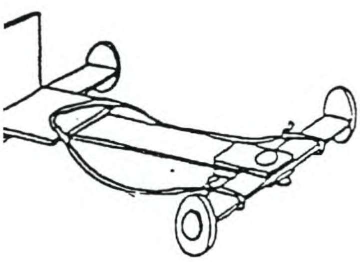
SCHOOL:

QUESTION 1

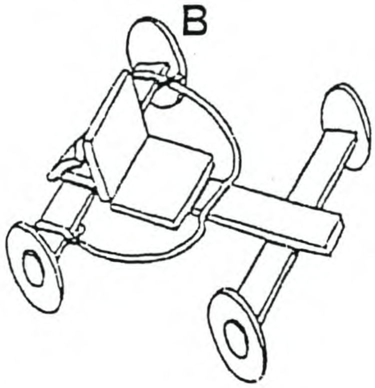
In a far off land where there are many poor people, there lives a little boy called Jonas. He is a kind and sweet boy and everyone in the village likes him. The problem is, Jonas cannot walk.

These go-karts were built by his friends to help him get around. Look carefully at the pictures and answer the following questions.

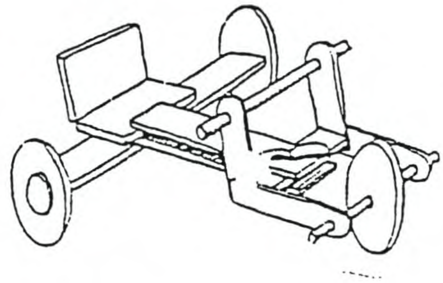
A



B



C



1.1 In what way(s) are A and B the same? ______________________________

____

1.2 In what way(s) are A and C the same? ______________________________

____

1.3 Is one of the go-karts more easily steered than the others? If so, which one? *Circle one:* A B C Why? ____________________

____

1.4 Which one is the least stable, and therefore more likely to turn over?

Circle one: A B C

1.5 Choose the go-kart that you think is the best overall design, and circle it in the pictures above. What could you add to the go-kart to slow it down going down a hill, because Jonas found that the kart goes too fast down slopes. Before you draw your ideas on the picture you circled, draw two or three ideas on the back of this page. Explain briefly how each idea would work, and why you think one would work better than the others. Then draw your best idea on the picture you circled.

QUESTION 2

Recycling is the name given to the process where used and wasted products are broken down and made into something useful.

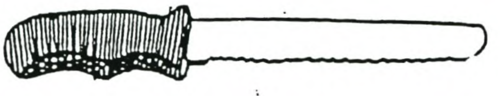
(Many people today prefer to buy a product that is recycled or environmentally friendly because it does less harm to the environment.)

Below is a list of some things that are often thrown away. Sort them into the correct category for recycling by ticking the correct column for each thing.

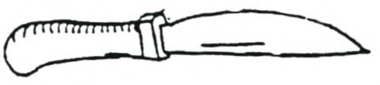
	Paper	Plastic	Metal	Glass	Plant matter
to peels					
spapers					
uce leaves					
tic bags					
ss cooldrink bottles					
boxes					
hurt cups					
ldrink cans					

QUESTION 3

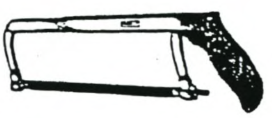
Look at the pictures below and read the words on the right side. The tools pictured below (on the left) are designed for cutting. The words (on the right) are materials or things that can be cut. Draw a line from each tool to the material which that tool would be most suited to cut.



metal/steel



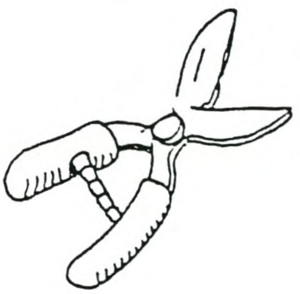
meat



grass

flowers

bread



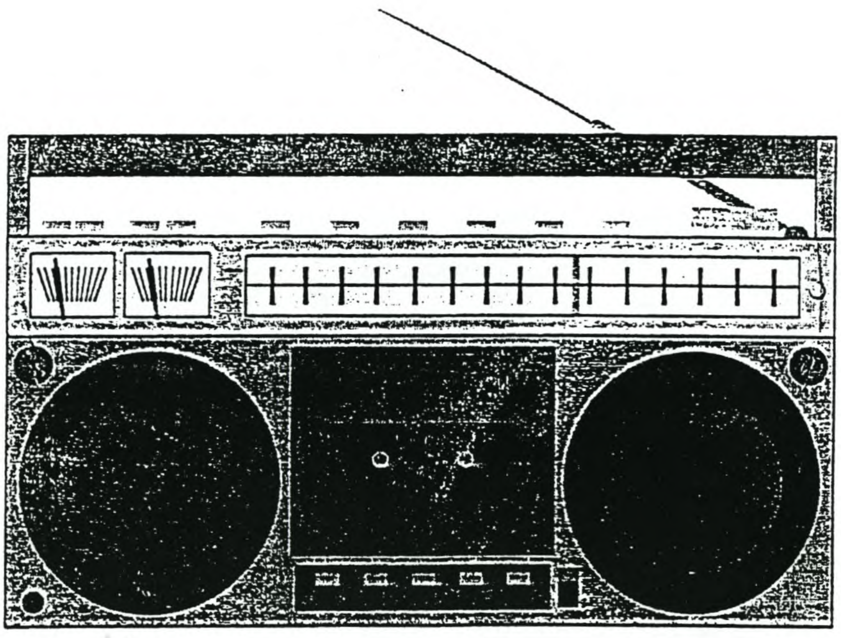
fabric

cardboard

QUESTION 4

On this page we have a picture of a radio and a list of words or labels for different parts of the radio, just above it. Match the words or labels to the correct part of the radio. First make your choice, then draw a line from the word you have chosen to the part of the picture you think matches it.

Aerial   Speaker   Dial button   Frequency display   Tape



INTERMEDIATE/SENIOR PHASE LEARNER'S SCHEDULE

SURNAME, NAME:

AGE:

GENDER:

GRADE:

TECHNOLOGY TEACHER NAME:

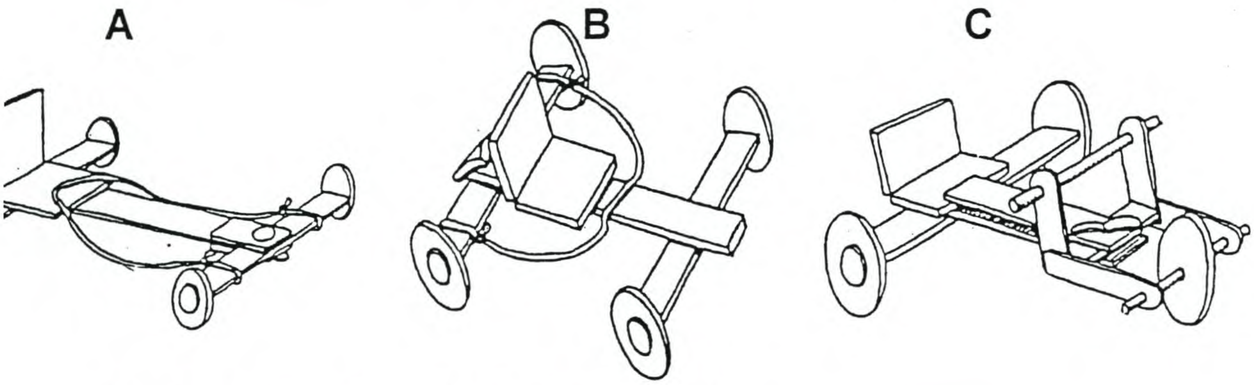
SCHOOL:

FOR INTERMEDIATE AND SENIOR PHASE

QUESTION 1

In a far off land where there are many poor people, there lives a little boy called Jonas. He is a kind and sweet boy and everyone in the village likes him. The problem is, Jonas cannot walk.

These go-karts were built by his friends to help him get around. Look carefully at the pictures and answer the following questions.



1.1 In what way(s) are A and B the same?______________________________

____

1.2 In what way(s) are A and C the same?______________________________

____

1.3 Is one of the go-karts more easily steered than the others? If so, which

one? *Circle one:* A B C Why?______________________

____

1.4 Which one is the least stable, and therefore more likely to turn over?

Circle one: A B C

1.5 Choose the go-kart that you think is the best overall design, and circle it in the pictures above. What could you add to the go-kart to slow it down going down a hill, because Jonas found that the kart goes too fast down slopes. Before you draw your ideas on the picture you circled, draw two or three ideas on the back of this page. Explain briefly how each idea would work, and why you think one would work better than the others. Then draw your best idea on the picture you circled.

QUESTION 2

Recycling is the name given to the process where used and wasted products are broken down and made into something useful.

(Many people today prefer to buy a product that is recycled or environmentally friendly because it does less harm to the environment.)

Below is a list of some things that are often thrown away. Sort them into the correct category for recycling by ticking the correct column for each thing.

	Paper	Plastic	Metal	Glass	Plant matter
ato peels					
wspapers					
s					
tuce leaves					
stic bags					
ss cooldrink bottles					
g boxes					
ghurt cups					
oldrink cans					

QUESTION 3

Processing food usually involves the following steps:

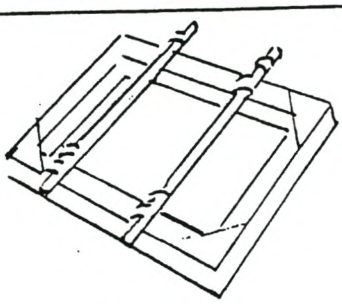
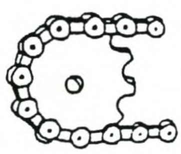
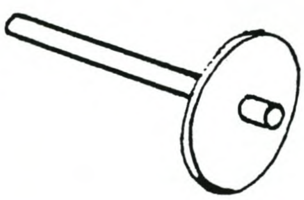
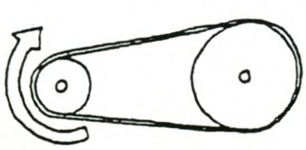
"INPUT" (FOOD IN) → MACHINE or TOOL → "PROCESS" (ACTION) → "OUTPUT" (FOOD OUT)

Complete the table below so that the machine or tool and the process will produce the correct output. The first example has been completed for you. In some cases, **more than one** answer may be correct.

Input	Machine	Process	Output
Mealies	☑ grinding stone ☑ mill ☐ whisk	☑ grinding ☑ crushing ☐ beating	mealie meal
Cream	☐ whisk ☐ beater ☐ churn	☐ beating ☐ boiled ☐ churning	butter
Egg	☐ mixer ☐ beater ☐ knife	☐ boiled ☐ beaten ☐ fried	omelette
Meat	☐ mincer ☐ electric saw ☐ knife	☐ grated ☐ shredded ☐ minced	mince
Potatoes	☐ knife ☐ grater ☐ carving knife	☐ sliced ☐ fried ☐ baked	chips

QUESTION 4

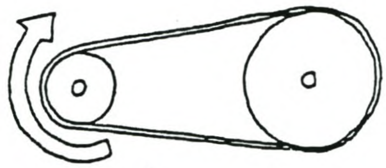
The mechanisms pictured below can increase force and decrease speed or distance travelled. Look at the diagrams below, and draw a line linking each of the diagrams (pictures) to the correct label.

	belt and pulley
	wheel and axle
	chassis
	chain and sprocket
	bevel gear
	worm and pinion gear

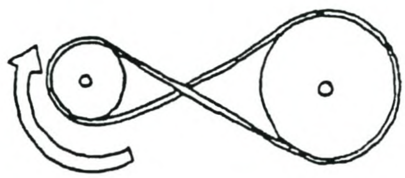
QUESTION 5

Look at the diagrams below. In each case, the left-hand wheel is rotating (turning) in a clockwise direction (to the right). Draw an arrow to indicate the direction the right hand wheel is turning. [In D, indicate (show) the direction that the other two wheels are turning.]

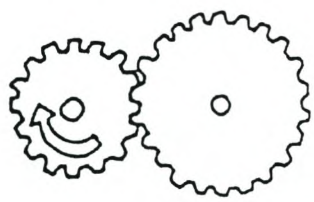
A



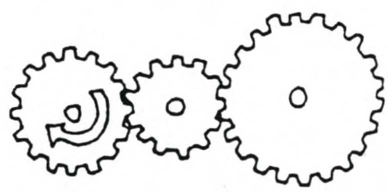
B



C



D



In two of the diagrams the direction of movement changes. In your own words, explain how this happens.

5.5 In ☐ it changes because

____

____

5.6 In ☐ it changes because

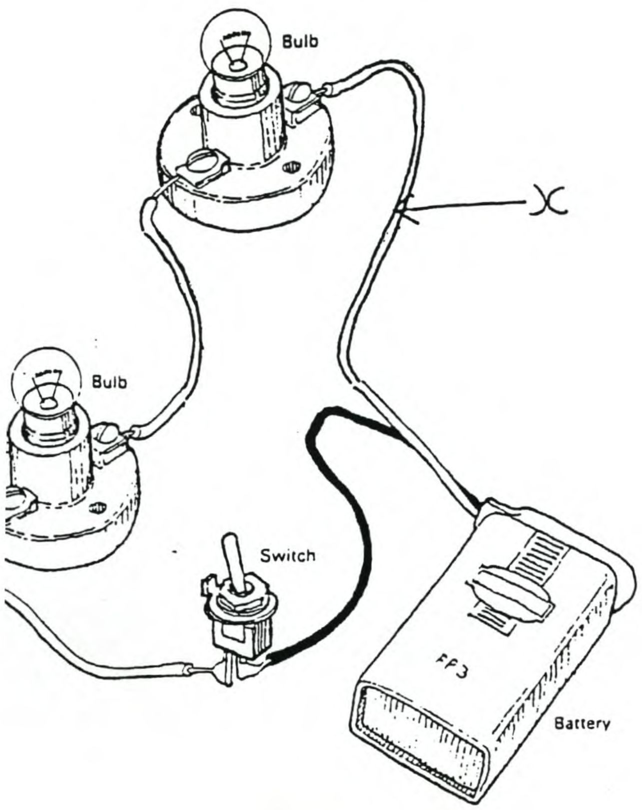
____

____

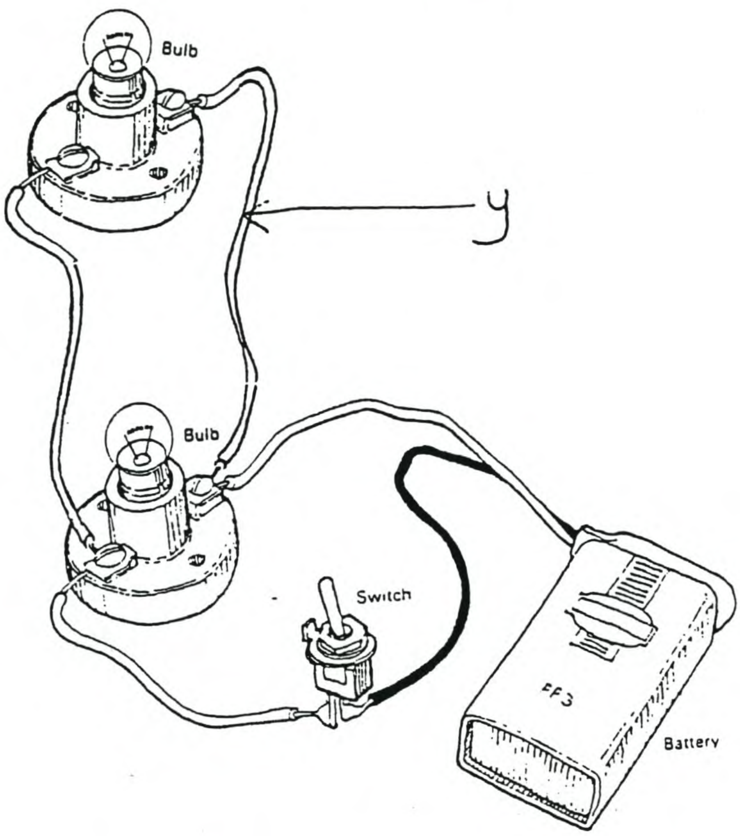
QUESTION 6

In each of these electric circuits pictured below, the light will glow when the switch closes the circuit.

A



B



6.1 What is the source of energy that allows the light to glow?

____

6.2 In which circuit (A or B) will the light glow brightest?________________

6.3 Why?____

____

6.4 What will happen if we break the circuit at X?________________

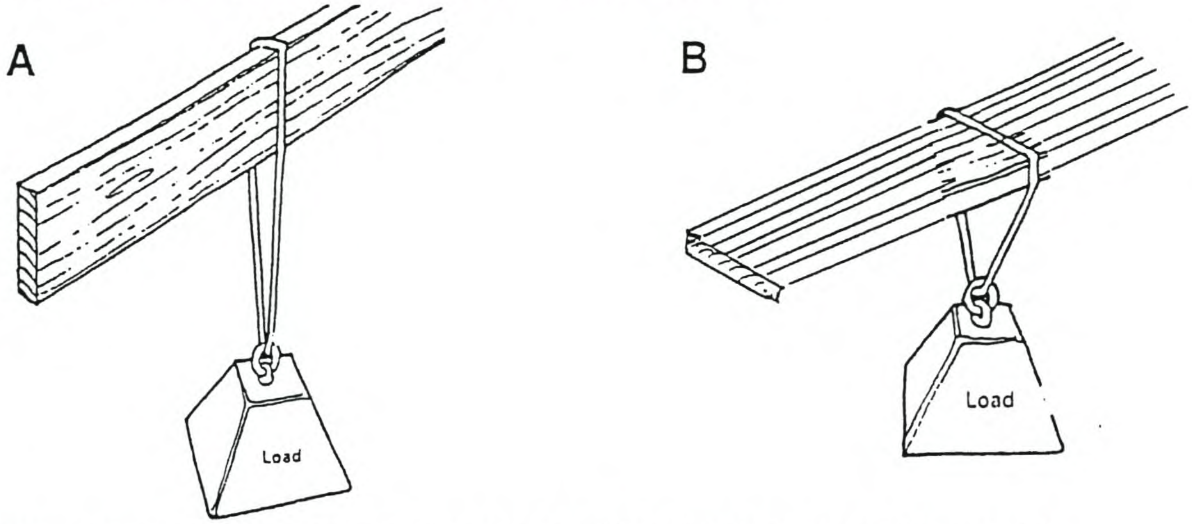
____

6.5 What will happen if we break the circuit at Y? ________________

____

QUESTION 7

Look carefully at the two diagrams below. In each case (A and B), both beams are the same size and both loads are the same weight.



7.1 Which beam is most likely to sag and bend if the weight of the load is increased? *Circle one:* A B

7.2 Why?____

____

Look at the three beams below.

7.3 Which is the strongest? *Circle one:* C D E

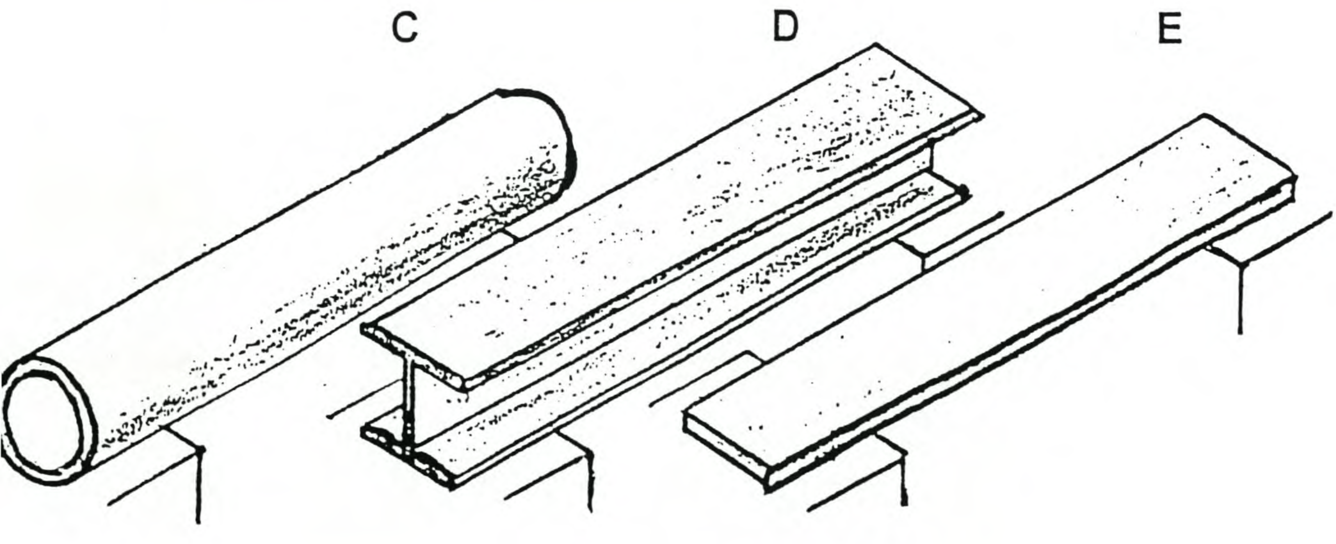
7.4 Why?____

____

7.5 Which is the weakest? *Circle one:* C D E

7.6 Why?____

____



PUT CONTROL SHEET FOR FACILITATORS

FACILITATORS MUST COMPLETE THE QUESTIONS BELOW FOR EACH CLASS AND EACH TEST GIVEN.

School:

Technology teacher's name:

Date of testing:

Number of schedules handed in:

Grade:

Total time:

Name of tester:

Observations by Tester:

UNIVERSITEIT VAN STELLENBOSCH
UNIVERSITY OF STELLENBOSCH

19 May 1999

TO WHOM IT MAY CONCERN

Re: Study to investigate learners' understanding of Technology

I hereby wish to request permission on behalf of **Margo Goldstone** to conduct the above-mentioned study in your school. The aim of this study is to determine the effect that Technology has on learners. This study is a continuation of *Technology 2005*, a National Implementation Evaluation project conducted in 1998 to investigate the implementation of Technology, one of the identified New Curriculum learning areas, in selected schools.

With your consent, a test will be administered to learners in selected grades and classes at your school. Information about learners' test performance will remain strictly confidential and will not be made available to anyone other than the research team. The researcher responsible for administering the test in your school, Ms Margo Goldstone, is currently a registered M.Phil. (Social Science Methods) student at the University of Stellenbosch, and will be using the collected data for her masters' thesis.

If you would like any further information or have any queries regarding the study, please contact me at telephone no. (021) 808-3708.

Thank you for your co-operation.

Professor Johann Mouton
Director - Centre for Interdisciplinary Studies
University of Stellenbosch

SENTRUM VIR INTERDISSIPLINÊRE STUDIE Universiteit van Stellenbosch, Stellenbosch 7600, Suid-Afrika

CENTRE FOR INTERDISCIPLINARY STUDIES University of Stellenbosch, Stellenbosch 7600, South Africa

FAX COVER SHEET

SCHOOL:

ATTENTION: THE PRINCIPAL

SENDER: MARGO GOLDSTONE
UNIVERSITY OF STELLENBOSCH
TEL: 903-0226 / 082 3044194

NO. OF PAGES INCLUDING THIS ONE: 2

MESSAGE

Details of the proposed study are as follows:

- I will require one Grade _ Technology class to participate in a paper-and-pencil exercise of approximately 45-60 minutes.
- This will hopefully take place within the next two weeks, i.e. before the 14th August 1999.
- Learners will be provided with all they require to perform the exercise (a booklet, pencil and paper).
- The class/technology teacher may be present during the exercise, but this is not a requirement as all instructions will be made explicit in the exercise.

The exercise examines student understanding(s) of Technology, but it does not narrowly follow the structure of the Technology curriculum. This is to accommodate for variability amongst schools in implementing the Technology curriculum. As such, the learners taking the exercise require no curriculum-specific Technology knowledge.

I will contact your school within the next two days, to secure your consent, and finalise the details.

Your co-operation would be highly appreciated.

Yours sincerely,
Margo Goldstone