# TECHNOLOGY EDUCATION IN SOUTH AFRICA SINCE 1998: A SHIFT FROM CONTENTS (CONCEPTUAL KNOWLEDGE) TO PROCESS-BASED LEARNING PROGRAMMES

Piet Ankiewicz, Estelle de Swardt en Werner Engelbrecht

*Department of Mathematics, Science, Technology and Computer Education, University of Johannesburg, Auckland Park Kingsway Campus, PO Box 524, Auckland Park, 2006, South Africa*

**Abstract**

The movement towards including technology education as a compulsory component in various educational systems has gained additional momentum since the 1980s. Although there is a distinction between conceptual knowledge ("knowing that") and procedural knowledge ("knowing how") in technology, these two types of knowledge cannot be separated. Conceptual or descriptive knowledge relates to the links between knowledge items, to such an extent that when learners can identify these links, we can say that they have conceptual understanding.

Procedural knowledge is frequently referred to as tacit, personal or implicit knowledge. In contrast with conceptual knowledge, procedural knowledge cannot be taught: "Technical know-how can be gained by thorough practice only" (Ropohl 1997, p. 69).

In learning programmes the content of technology cannot unilaterally include conceptual knowledge of technology as artefacts, but should also contain procedural knowledge on the design and making of such artefacts, and vice versa. However, it is problematic to include both types of knowledge, of which procedural knowledge cannot be taught, simultaneously in learning programmes. The purpose of this paper is to determine which shifts in emphasis concerning the inclusion of conceptual and procedural knowledge are necessary in technology learning programmes, using the philosophy of technology as a point of departure, and to indicate briefly how both of them can be included in the RAUTEC learning programmes.

This paper argues that the explicit development of both the normally tacit procedural knowledge (in the form of a ten stage model mainly within the rational problem-solving paradigm as well as the application and development of complex thinking) and the conceptual technological knowledge should form the core of learning support materials in technology.

Key words: conceptual knowledge, procedural knowledge, process-based learning, learning programme

INTRODUCTION

The movement towards including technology education as a compulsory component in various educational systems has gained additional momentum since the 1980s (Mawson 2003, p. 117). Worldwide, technology education has been introduced officially into schools in England and Wales for the first time in 1990 and as recently as 1994 in the Netherlands. In South Africa it has been a given in Curriculum 2005 since 1998 and compulsory for the first nine school years.

Technology has its own distinctive characteristics which makes it essentially different from other things (Ankiewicz 1995, p. 250; ITEA 1997, p. ii). Although there is a distinction between conceptual knowledge ("knowing that") and procedural knowledge ("knowing how") in technology (McCormick 1997, p. 143; Ryle 1949, pp. 28-32; Ropohl 1997, p. 69), these two types of knowledge cannot be separated (McCormick, 1997:145). Conceptual or descriptive knowledge relates to the links between knowledge items, to such an extent that when learners can identify these links, we can say that they have conceptual understanding. Conceptual knowledge relevant to technology includes "... that drawn from other subjects, such as science, and that unique to technology" (McCormick 1997, p. 153).

Procedural knowledge is frequently referred to as tacit, personal or implicit knowledge. "Design, modelling, problem solving, systems approaches, project planning, quality assurance and optimisation are all candidates for technological procedural knowledge …" (McCormick 1997, p. 144). In contrast with conceptual knowledge, procedural knowledge cannot be taught: "Technical know-how can be gained by thorough practice only" (Ropohl 1997, p. 69).

Established in 1999, the RAU Centre for Technology Education (RAUTEC) was the first school/university-based technology centre of its kind in South Africa. One of RAUTEC's aims is to promote technology education as part of Science, Engineering and Technology (SET) through instruction, research and community service, especially within the framework of the national education policy. Another of its aims is to develop and provide outcomes-based learning support material for school learners and support material for technology educators. One of the notable successes of RAUTEC is the development of learner and educator support material. RAUTEC started in 2000 with the development of learning material for Grade 8 and 9 learners and four modules were developed for Grade 7 learners in 2004. Of the 300 000 learner workbooks and 15 000 facilitator guides distributed since 2001, no fewer than 120 000 have been distributed since 2004.

It soon became clear that the traditional methods of developing learning programmes, which rely heavily on conceptual knowledge, were not adequate for the RAUTEC learning programmes. In learning programmes the content of technology cannot unilaterally include conceptual knowledge of technology as artefacts, but should also contain procedural knowledge on the design and making of such artefacts, and vice versa: "… it is the possession of conceptual knowledge that makes possible the effective use of procedural knowledge of problem solving" (Glaser 1984; in McCormick 1997, p. 149). However, it is problematic to include both types of knowledge, of which procedural knowledge cannot be taught, simultaneously in learning programmes. Given the philosophy of technology as point of departure it is the purpose of this paper to determine which shifts in emphasis concerning the accommodation of conceptual and procedural knowledge are necessary in technology learning programmes, and to indicate synoptically how they may be accommodated in the RAUTEC learning programmes.

Taking into account the purpose of the paper, the following research questions are answered:

1. What is the nature of the conceptual and procedural knowledge of technology from an epistemological and methodological perspective?
2. What are the implications of the two types of technological knowledge for the development and structuring of learning programmes?

In contrast to the other learning areas where a well-founded subject philosophy exists at least for particular components, there is as yet no established subject philosophy for the Technology learning area – in fact, the dynamic nature of technology as such leaves its own philosophy in a tentative or flexible state. Learning programmes for technology education and its facilitation at chalk level often lack a scientifically founded subject philosophical framework (Moreland & Jones 2000, p. 284; Van Niekerk 2003, pp. 8-9). Matters are complicated by the fact that technology education at school level is globally a developing learning area where no equivalent academic discipline exists which can serve as a basis for curriculum development (De Vries 2001, p. 26; De Vries 2003c, p. 83).

## A PHILOSOPHICAL FRAMEWORK FOR TECHNOLOGY

A philosophical framework for technology needs to take into account that the term “technology” can have both a narrow and a wide meaning in its present discourse, which roughly coincide with the manner in which two professional groups, namely engineers and social scientists respectively employ the term, and which lead to tension between the two uses (Mitcham 1994, p. 143). The concept “technology” has mainly been reserved by engineers where there is a direct involvement with material construction and the manipulation of artefacts (Mitcham 1994, p. 147).

In the social sciences the concept “technology” also includes making material artefacts, the completed objects, their usages and to a limited extent also the intellectual and social contexts. Sometimes technology is defined in such a way that it includes making non-material things like laws and language (Mitcham 1994, p. 150). The tension between the narrower engineering usage of the word “technology” and its broader use in the social sciences cannot be clearly resolved, and should at most be accommodated.

A further implication of a philosophical framework is the numerous, apparently incompatible definitions of technology continually appearing in discussions. The disagreements at issue call for a more open description of technology that delineates its different types and their interrelationships: “… what is needed is not a definitional but characterological framework” (Mitcham 1994, pp. 152-153). This is also the reason why we deliberately avoid giving a definition of technology and rather wish to focus on a framework or typology based on an analysis of the various types of technology.

In this regard Mitcham (1994, pp. 154-160) proposed a preliminary framework based on preliminary and inadequate typologies (those of Schuurman, Teichmann, Bunge, Carpenter, McGinn and Kline) taking additional criteria into account. Mitcham’s framework consists of the four modes of the manifestation of technology: technology as object, technology as knowledge, technology as activity, and technology as volition (De Vries 2003a, p. 2; Custer 1995, p. 219).

Next we want to give an overview of some key aspects of the modern philosophy of technology based on two of Mitcham’s four modes in which technology manifests itself, by viewing it from philosophical, historical and practice-based design methodological perspectives.

TECHNOLOGY AS KNOWLEDGE (EPISTEMOLOGY/THEORY OF KNOWLEDGE)

Technology as knowledge, the second mode in which technology is manifested, has most frequently been the subject of analytical investigations in the epistemology or theory of knowledge, according to Mitcham (1994, p. 192). In its simplest form epistemology (theory of knowledge) is the systematic study and ordering of knowledge (Van der Walt et al. 1985, p. 192). Etymologically, the concept techno-logy (as with bio-logy and socio-logy) indicates that it is concerned with knowledge. The epistemology of technology has its basis in theoretical reflections and more recently in empirical studies as well (Broens & De Vries 2003, pp. 3-4, 6; Ropohl 1997, p. 67).

Technology as knowledge can be distinguished according to various types of knowledge, for example maxims, rules, theories etc (Mitcham 1994, p. 268). Although there is a distinction between conceptual knowledge ("knowing that") and procedural knowledge ("knowing how") in technology (McCormick 1997, p. 143; Ryle 1949, pp. 28-32; Ropohl 1997, p. 69), these two types of knowledge cannot be separated (McCormick 1997, p. 145).

Conceptual or descriptive knowledge relates to the links between knowledge items, to such an extent that when learners can identify these links, we can say that they have conceptual understanding. "Thus in the area of 'gearing' we hope that students will see the relationship among the 'direction of rotation', 'change of speed', and 'torque'" (McCormick 1997, p. 143). Conceptual knowledge that can be regarded as knowledge of apparatus or systems (Gott 1988; in McCormick 1997, p. 148) is clearly knowledge of technology as artefacts (Mitcham 1994). Conceptual knowledge relevant to technology therefore includes "... that drawn from other subjects, such as science, and that unique to technology" (McCormick 1997, p. 153).

Procedural knowledge is frequently referred to as tacit, personal or implicit knowledge. "Design, modelling, problem solving, systems approaches, project planning, quality assurance and optimisation are all candidates for technological procedural knowledge …" (McCormick 1997, p. 144). In contrast with conceptual knowledge, procedural knowledge cannot be taught: "Technical know-how can be gained by thorough practice only" (Ropohl 1997, p. 69).

A theory of knowledge usually includes methodology (Van der Walt et al. 1985, p. 192), but seeing that Mitcham (1994) classified methodology as one of the modes in which technology is manifested, it is dealt with separately. Technology as activity (methodology) in particular, provides insights in the procedural knowledge in technology.

In the literature one finds examples of considerations of the epistemology of technology from a philosophical (Ropohl 1997, pp. 67-70), historical (Vincenti 1990, pp. 207-225) and practice-based design-methodological perspective (Bayazit 1993; Muller & Pasman 1996; in Broens & De Vries 2003, p. 6). Due to time constraints every classification of technological knowledge cannot be discussed here. From a philosophical perspective De Vries (2003a; 2003b; 2003c) compared existing classifications with their origins from various viewpoints and composed his own classification that can be linked to particular aspects of existing typologies. De Vries's four categories are only applicable to conceptual knowledge ("knowing that") expressed in propositions and not to procedural knowledge ("knowing how") that, unlike conceptual knowledge, cannot be expressed completely in propositions. It is impossible, for example, to explain comprehensively to a person how to ride a bicycle in propositions.

De Vries's (2003a; 2003b; 2003c) simpler representation of the epistemology of technology, which is not necessarily less complex than Vincenti's, will be taken as epistemological point of departure for this address. De Vries's starting point is the dual nature of technological artefacts: "... they are designed physical structures which realise intentionality-bearing functions" (Kroes & Meijers 2000, p. xxv). Technological artefacts cannot completely be described within the physical conceptualisation, because it leaves no room for functional characteristics. Furthermore, they cannot be comprehensively described within intentional conceptualisation, because their function needs to be realized within an appropriate physical structure. Based on the LOCal Oxidation of Silicon (LOCOS) and Optical Communication Systems case studies (De Vries 2003b, p. 12) in the Philips Natuurkundige Laboratorium (Eindhoven, Nederland) De Vries distinguishes four types of conceptual knowledge ("knowing-that") relevant to the development of technological artefacts. These are knowledge of its physical nature; knowledge of its functional nature; knowledge of the relationship between its physical and functional nature; and process knowledge (De Vries 2003c, p. 84; Broens & De Vries 2003, pp. 5-6; De Vries 2003b, p. 2; De Vries 2003a, pp. 13-14).

Knowledge of a physical nature: X knows that an artefact has physical characteristics. For example X knows that a cork screw consists of a helix with a sharp point.

Knowledge of a functional nature: X knows what the artefact, which may not as yet exist, is capable of doing. For example X knows that a cork can be removed from a bottle neck by gripping the cork and pulling it out (and that a cork screw is a device for doing this).

Knowledge of the relationship between physical and functional nature: X knows that a particular physical characteristic or combination of characteristics of an artefact enables it to perform an action. For example X knows that the sharp helix of a corkscrew enables it to get a grip on the cork (for it to be removed from the bottle neck).

Process knowledge: X knows that the cork can be removed from the neck of the bottle by first inserting the helix into the cork and then to pull at the handle of the corkscrew.

TECHNOLOGY AS ACTIVITY (METHODOLOGY)

The third mode in which technology is manifested is technology as activity: “Technology includes more than material objects such as tools and machines and mental knowledge or cognition of the kind found in engineering sciences … despite the quickness with which people think of physical objects … when ‘technology’ is mentioned … activity is arguably its primary manifestation. Technology as activity is that pivotal event in which knowledge and volition unite to bring artefacts into existence or to use them; it is likewise the occasion for artefacts themselves to influence the mind and will” (Mitcham 1994, p. 209).

Technology as activity is recognizable in terms of various activities, for example, making, design, maintaining and use (Mitcham 1994, pp. 210, 268). Mitcham (1994, pp. 216-225) makes a meaningful distinction between invention and design. In contrast with scientific discovery, technological inventions refer to the creation of something new, rather than to finding an existing thing that was hidden. Innovation as a form of invention is “The slowed-down or spread-out invention through innumerable minor modifications that maintain historical continuity …” (Mitcham 1994, p. 217).

Invention, as opposed to design, is apparently an action preceded by non-rational, unconscious, intuitive and even accidental ways of doing. Invention can thus be viewed as accidental design. “Modern engineering, as an attempt to settle and systematize the inventive process, has been called the ‘invention of invention’: ‘The greatest invention of the nineteenth century was the invention of the method of invention. …’” (Mitcham 1994, p. 217). Design can be described “… as the attempt to solve in thought, using available knowledge, problems of fabrication that will save work (as materials or energy) in either the artefact to be produced, the process of production, or both … Engineering design is thus an effort (at first sight of a mental sort) to save effort (of a physical sort)” (Mitcham 1994, pp. 220-221).

Although a distinction is made in technology between design and problem-solving (McCormick 1997, pp. 150-153; Johnsey 1995, pp. 199-200), there is a connection between these concepts: The design process is seen as the manifestation of the problem-solving process (McCormick et al. 1994, p. 5). According to De Vries (in ITEA, 1997, chapter 3:7) design is a particular type of problem-solving in technology. Various kinds of complex thinking processes (creative and critical thinking, decision-making and problem-solving) underpin and form part of technological activities (Sharpe 1996, p. 29; Johnson 1997, p. 163; De Swardt 1998, p. 4; Ankiewicz & De Swardt 2002, p. 77; Jakovljevic 2002, pp. 79-80; Reddy, Ankiewicz, De Swardt & Gross 2003, p. 30) – therefore, technology can be regarded both as "minds-on" (complex thinking) and as "hands-on" (practical activities) (McCormick & Davidson 1996, p. 232).

Design processes are the object studied in the discipline of design methodology (De Vries 2001, p. 26). The point of departure for design methodology is the experiences of active designers, and reflection on these experiences leads to general insights in design processes and methods (Broens & De Vries 2003, p. 3). The overall aim of design methodology is to improve the effectiveness and efficiency of design activities, and to develop design as a discipline through critical consideration of design (Dorst 1997, p. 8).

Two radically different paradigms form the basis of the discipline of design methodology (Dorst 1997, pp. 11-12):

- The rational problem-solving paradigm (based on the work of Simon, 1969) where “objective” observation and logical analysis lead to general, formal design models and pave the way for objective interpretation – the structured approach generally associated with engineers.
- The reflective practice paradigm (as proposed by Schön, 1983) that moves the focus from general design models to the uniqueness of every design problem, where reflective communication with the situation takes place and there is room for subjective interpretation – a less structured approach usually associated with architects (Dorst 1997, p. 204).

Dorst (1997, p. 133) distinguished three phases during the design activity: the conceptual phase, the information phase and the embodiment phase. All three phases can easily be related to the rational problem-solving paradigm, while the conceptual phase is the only one relevant to the reflective paradigm. The conceptual phase of the design process is a more subjective design activity and is therefore more adequately described by the reflective practice paradigm. During the information phase of a design project most of the design activities involve objective interpretation and it is therefore better described by the rational problem-solving paradigm (Dorst 1997, p. 162).

## DISCUSSION

In the previous section the nature of technological conceptual and procedural knowledge was briefly discussed from an epistemological and methodological point of view. Our attention will now shift to the implications of the epistemology (conceptual knowledge) and methodology (procedural knowledge) of technology for developing and structuring learning programmes.

### Broad instructional approach

The instructional approach should not in the first place be solely determined by the education policy of the day, but rather by the philosophy (nature and essence) of the field/learning area. Education policy could certainly be required to be formulated so broadly that it can accommodate the philosophy of a specific learning area. For instructional approaches and programmes in technology to be relevant, they should be based on the relevant four modes (Mitcham 1994) in which technology is manifested (De Vries 2003a, p. 2). Because "… (learner) activity is that pivotal event in which knowledge and skills unite to bring artefacts into existence …" (Mitcham 1994, p. 209), technology education should in its deepest nature also be processed-based and constructivist, paving the way for truly outcomes-based education (OBE) – and with truly we mean that it should as far as possible be stripped of all ideological and political overtones.

For the purpose of this paper OBE and the accompanying arguments why education and training in South Africa were changed to be based on the principles of OBE are not defined or argued. According to Killen (2000, pp. vii, xiv-xv) all decisions pertaining to planning, teaching, assessment and evaluation in OBE are determined by the following four principles:

- The **outcomes** educators want learners to achieve;
- The **content** used by educators to help learners in achieving the outcomes;
- The **process (instructional approach and strategies)** educators employ to assist learners in achieving the outcomes;
- The **assessment** of learners.

The discussion of the implications of the conceptual and procedural knowledge of technology for developing and structuring learning programmes will be structured around these principles.

## Learning outcomes

The **learning outcomes** should, apart from particular policy directives, include the epistemology and methodology of technology. Learning outcomes cannot be achieved in a vacuum, and therefore learning content (as included in the epistemology and methodology) is the tool for learners to achieve the outcomes: "… when you consider the content that you will use to help learners achieve the outcomes ..." (Killen 2000, p. xiv). Although different to the directives of OBE it could be meaningful to first identify the learning content of technology in an unorthodox way and then to determine what learning outcomes will be instrumental in achieving these. In this way the starting point of outcomes in essence also becomes the end point. For this reason educators need to be familiar with the philosophical framework of technology (Moreland & Jones 2000, p. 284; Van Niekerk 2003, pp. 8-9). Reddy et al. (2003, p. 29) contend "… that technology teachers' inability to make technological experiences 'cumulative', 'purposeful' and 'empowering' resides in their inability, for example, to see the inter-relationship between technological content knowledge, skills, attitudes and values and technological capability". The various modules developed at RAUTEC are structured in units. Units are structured according to the various learner tasks (resource, case study, capability tasks) and/or a stage or a grouping of the stages of the technological process (procedural knowledge). Unit outcomes therefore support the module outcomes, which in turn support the Specific Outcomes as prescribed by the national curriculum.

## Content (as learner activities) and educator activities

Traditionally three types of content are recognized: knowledge, skills (not only psychomotor but also cognitive skills) and attitudes/the affective. **Knowledge as content** should primarily be guided by the epistemology, without disregarding the other aspects. **Skills as content** are mainly directed by methodology and the **affective as content** by volition. Although the content of technology can be divided into three distinguishable components, these are not separable: "A learner cannot 'do' technology (procedural knowledge) without knowing (conceptual knowledge) and having the desire to do so (affective component)" (Ankiewicz et al. 2001, p. 95).

Initially there was the myth, especially in South Africa, that the OBE approach drew a line through conceptual (factual) knowledge, to such an extent that textbooks normally containing this became redundant. "A constructivist approach to instruction and learning does not deny the importance of factual knowledge, but it does emphasise that the best way for learners to retain and apply this knowledge is to ‘put it into a larger, more lifelike context that stimulates learners to reflect, organize, analyse, and problem solve’” (Borich & Tombari 1997; in Killen 2000, p. xx). In learning programmes the content of technology cannot unilaterally include conceptual knowledge of technology as artefacts, but should also contain procedural knowledge on the design and making of such artefacts, and vice versa: “… it is the possession of conceptual knowledge that makes possible the effective use of procedural knowledge of problem solving” (Glaser 1984; in McCormick 1997, p. 149). “As the complexity of devices increases so does the importance of the interaction of device knowledge and procedural knowledge” (Gott 1988; in McCormick 1997, p. 149).

Technological procedural knowledge is not associated with technical skills but with thinking processes and skills (McCormick 1997, p. 144). It has already been indicated that “… technical know-how implies cognitive resources …” (Ropohl 1997, p. 69), and that complex thinking processes are part of technological activities.

Based on the rational problem-solving paradigm a stage model can be used to assist learners in developing procedural knowledge (which per definition may be tacit) through practice and which can serve as explicit organisational framework for the educator and learner (McCormick et al. 1994, p. 7; McCormick 1997, p. 151; Mawson 2003, p. 119). It is general practice in technology education to present the procedural knowledge of technology in a stage-oriented format in models (Johnsey 1995; Jones 1997; GDE & GICD, 1999; Ankiewicz et al. 2000). Most models of the technological process represent it as a linear process assuming that the process proceeds in a particular sequence (Johnsey 1995, pp. 202-205; Mawson 2003, p. 118).

In the context of a developing country with a shortage of adequately qualified educators, it is vital to provide teachers with as many guidelines as possible. Therefore, RAUTEC uses a ten-stage model for procedural knowledge as organisational framework for the learning programme.

- The following is a brief description of each of the ten stages of the technological process:
- *Statement of the problem* refers to the identification of the problem, need or want in the form of a short descriptive sentence;
- *Design brief* is the general outline of the intention how to solve the problem specifying special requirements and the context or the environment;
- *Investigation* is the process of gathering information related to the problem, needs or wants as identified in the first stage;

- *Proposal* implies a formal, written commitment of what needs to be made or designed in order to meet the need or want, or to solve the problem. The proposal consists of a written description of the specification for the product, as well as a time plan indicating how long the project will take to complete.
- *Initial ideas* imply generating ideas, discussion, analysis and choosing the best idea or combination of ideas;
- *Research:* During this stage an investigation is undertaken to solve problems and answer questions with regard to problematic aspects of the chosen idea, in order to develop it into a workable solution. Research implies a more in depth and more specific search for information, than the initial investigation.
- *Development* refers to the refinement of the chosen idea by applying the research results to the problematic aspects;
- *Planning* refers to planning on how to make, assemble and finalize the product. The final idea is represented in a work drawing. The various drawings can be used to indicate different parts of the proposed system and the relationships between the components. A list of required resources is compiled and installed;
- *Realisation/Making* consists of the production of a product. It includes the realisation of the planning and designing into a product;
- *Testing, Evaluation and Improvement* involve the testing and a final evaluation of the product based on the criteria included in the Design brief and Proposal (Ankiewicz & De Swardt 2002, p. 76; Jakovljevic, Ankiewicz, De Swardt & Gross 2004, pp. 264-265)

One also finds models with iterative design activities in the form of a loop (Todd 1990; Johnsey 1995; Garratt 1998; Mawson 2003). Each stage of the technological process requires learners to apply some of the sub-processes of complex thinking (Ankiewicz & De Swardt 2002, p. 77).

The RAUTEC workbooks provide for the interaction between conceptual and procedural knowledge. The procedural knowledge is the stages to which specific thinking processes are linked. The conceptual knowledge that relates to the specific theme, is specifically imported into the investigation and research stages. Conceptual knowledge that relates to tools (as existing technology) is imported into the making stage. Conceptual knowledge that relates to graphic communication is imported into the idea generation and planning stages. The conceptual knowledge encompasses De Vries's four categories. Thorough practice of the procedural knowledge is acquired by learners by giving them the opportunity to follow the same stages of the technological process throughout the series, which consists of up to seven different modules.

The danger inherent in these stage-oriented models is that learners: "… follow it like a ritual exhibiting a veneer of accomplishment while actually following their own process of design … or are totally unaware that there is a process (procedural knowledge) to be learnt" (McCormick 1997, p. 151; Mawson 2003, p. 120). From design methodology it also became clear that the conceptual phase of a design project can be described more effectively by the reflective paradigm (Dorst 1997, p. 162), and therefore learners should be provided with opportunities for reflective design.

A deficiency in the RAUTEC learning programmes is probably too little exposure to reflective design. However, there are modules where learners must make a complete design towards the end of the module by applying the technological process. Nothing prohibits them from then working reflectively and then documenting it as if the process were linear.

Although positive feedback concerning the RAUTEC learning programmes is often received the research regarding the impact of the ways in which the conceptual en procedural knowledge is accommodated in the modules/learning programmes is still in its infancy stage.

CONCLUSION

From a philosophical perspective the epistemology and methodology have cast light on the nature of the conceptual and procedural knowledge of technology. A few implications for developing and structuring learning programmes have been deducted:

- In the case of technology education, compared to other learning areas, the shift to outcomes-based education (OBE) was not obligatory, but spontaneous, as technology education should be process-based and constructivist in its deepest nature. In spite of this the inclusion of conceptual knowledge in learning programmes is not less important.
- Both conceptual and procedural knowledge are important tools for learners to achieve the learning outcomes.
- Instead of the over-emphasis on the reproduction of factual knowledge in the past complex thinking now constitutes an important aspect of procedural knowledge which should be included in learning programmes.
- In context of a developing country a stage model for procedural knowledge, based on the rational problem-solving paradigm, may be used to assist learners to develop procedural knowledge and to serve as organisational framework for the educator and the learners.

- A reflective practice paradigm can be used when technology educators are highly competent.

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**Principal Author**:

**Prof Piet Ankiewicz**

Prof Piet Ankiewicz holds an M.Sc. (Physics) and a D.Ed. both from Potchefstroom University for Christian Higher Education. He is professor in technology education at the University of Johannesburg, with special interest in the philosophical and theoretical foundation of technology education, instructional methodology, learning programmes and learners' attitudes towards technology. He teaches and researches in these areas, and is also appointed Head of the RAU Centre for Technology Education (RAUTEC).

His address is:

Department of Mathematics, Science, Technology and Computer Education

University of Johannesburg

Auckland Park Kingsway Campus

P.O. Box 524

AUCKLAND PARK

2006

South Africa

Tel. +27-11-489-2640

Fax: +27-11-489-2048
E-mail: pja@rau.ac.za

**Co-Authors:**

**Prof Estelle de Swardt**

Prof Estelle de Swardt holds an M.Ed. (Technology education) and a D.Ed. both from the Rand Afrikaans University. She is an associate professor at the University of Johannesburg and is presently involved in the training of teachers for technology education with a special focus on critical and creative thinking development.

Her address is:
Department of Mathematics, Science, Technology and Computer Education
University of Johannesburg
Auckland Park Kingsway Campus
P.O. Box 524
AUCKLAND PARK
2006
South Africa
Tel. +27-11-489-2695
Fax: +27-11-489-2048
E-mail: aeds@rau.ac.za

**Mr Werner Engelbrecht**

Mr Werner Engelbrecht holds a B.Ed. Hons. (Technology Education) from the Rand Afrikaans University. He is a lecturer in technology education at the University of Johannesburg, with special interests in teacher education, continuous professional development and developing learner support material. He teaches and researches in these areas, and is also appointed Manager of the RAU Centre for Technology Education (RAUTEC).

His address is:
Department of Mathematics, Science, Technology and Computer Education
University of Johannesburg
Auckland Park Kingsway Campus
P.O. Box 524
AUCKLAND PARK

2006

South Africa

Tel. +27-11-489-3528

Fax: +27-11-489-2048

E-mail: we@rau.ac.za