THE ALIGNMENT OF THE CAPS FOR TECHNOLOGY IN THE SENIOR PHASE WITH THE PHILOSOPHY OF TECHNOLOGY: A CRITICAL ANALYSIS

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Abstract: The Curriculum and Assessment Policy Statement (CAPS) for Technology in the senior phase will be officially implemented in 2014. Responses to the intended curriculum, both positive and negative, arise from various stakeholders and interest groups. However, in the absence of scientifically founded criteria for the evaluation of intended technology curricula it is often not clear whether such responses are justified, and subsequently it is impossible to make fair judgments about the CAPS for Technology in the senior phase. Based on Mitcham's framework (1994), relevant literature reports on a philosophical framework of technology that consists of four modes of the manifestation of technology, namely: object, knowledge, activity, and volition (Custer, 1995; De Vries, 2003a). This conceptual paper reports on desktop research with the purpose of investigating how a scientifically founded, philosophical framework of technology may be directive to the evaluation of the intended CAPS for Technology in the senior phase. Based on the philosophy of technology it was found that an extensive set of criteria may be derived for the evaluation of intended technology curricula. The extent to which the CAPS for Technology in the senior phase is aligned with the aforementioned criteria is also discussed. The CAPS is in agreement with the epistemology of technology to a reasonable extent. It falls short mainly regarding the promotion of thinking processes and thinking skills. It over-emphasises the impact of technology, possibly at the expense of aspects such as innovation, which is underpinned by thinking skills.

Keywords: Technology education, philosophical framework, curriculum evaluation, The Curriculum and Assessment Policy Statement (CAPS)

1.1 INTRODUCTION

Technology is globally still a relatively new school subject that lacks a substantive research base and a well-established classroom pedagogy (Mawson, 2007; Rauscher, 2011,). Unlike other school subjects where a well-established, subject-based philosophy exists at least for particular components, there is as yet no established philosophy for technology as subject – in fact, the dynamic nature of technology as such leaves its own philosophy in a tentative and flexible state. Curricula and learning programmes for technology education and their facilitation at chalk level thus often lack a scientifically founded, subject-based philosophical framework that may serve as a directive (Moreland & Jones, 2000; Van Niekerk, 2003; Van Niekerk, Ankiewicz & De Swardt, 2010).

Matters are complicated by the fact that technology at school level is globally a developing subject with no equivalent academic discipline which may serve as a source upon which curriculum development and classroom pedagogy may rely in practice (Ankiewicz, De Swardt & De Vries, 2006; De Vries, 2001; De Vries, 2003a). In contrast, mathematics as school subject, for example, is based on the academic discipline of mathematics with an established, scientifically founded, subject-based, philosophical framework which has been developed over centuries.

An epistemological aspect frequently coming to the fore is the nature of the relationship between the knowledge of the natural sciences and technological knowledge (Ankiewicz, De Swardt & De Vries, 2006). In general, those who adhere to the positivist tradition in the philosophy of natural science would argue that technology is actually applied science (the accepted viewpoint of engineers and scientists and Mario Bunge, as their strongest philosophical representative). They would endeavour to build an epistemology of technology based on the encompassing model based on scientific laws for its explanatory power (Mitcham, 1994).

In contrast to Bunge's view of technology as applied science, one also finds the view according to which there is no deducible link between one or more elements of technological knowledge and natural science, or that they are totally incompatible (Mitcham, 1994; Custer, 1995). Rauscher (2012) warns that an educational approach that follows a technology-is-applied-science model might lead to a misrepresentation of the historical and epistemological relationship between natural science and technology. This might also present an inaccurate image of the nature of technology as activity/methodology. It is for this very reason that the researcher is hesitant to rely on the view of technology as 'the application of science`, and that this could be a traceable anchor as an academic discipline for technology.

It is against the above background that the Curriculum and Assessment Policy Statement (CAPS) for Technology in the senior phase will be officially implemented in 2014 (DoBE, 2011). Responses to the intended or specified curriculum, either positive or negative, arise from various stakeholders and interest groups. However, in the absence of scientifically founded criteria for the evaluation of intended technology curricula it is often not clear whether such responses are justified, and subsequently it is impossible to make fair judgments about the CAPS for Technology in the senior phase.

Based on Mitcham's framework (1994), the literature reports on a philosophical framework of technology that consists of four modes of the manifestation of technology, namely: object, knowledge, activity and volition (Custer, 1995; De Vries, 2003a). These are directives for technology classroom pedagogy (Ankiewicz, 2013a), technology teacher education (Ankiewicz, 2013b) and for science, technology and society (STS) studies (Ankiewicz, De Swardt & De Vries, 2006).

This conceptual paper reports on desktop research with the purpose of investigating how a scientifically founded, philosophical framework of technology may be directive to the evaluation of the intended CAPS for Technology in the senior phase. The following research questions serve as point of departure for the theoretical reflection that underpins the paper:

1. Based on the four modes of the manifestation of technology – namely as object, knowledge, activity, and volition – which scientifically founded criteria may be derived to be applied as part of the evaluation of intended technology curricula?
2. To what extent is the intended CAPS for Technology in the senior phase aligned with the aforementioned criteria for curriculum evaluation?

The philosophy of technology establishes the philosophical foundations for technology as a field of human endeavour (Forret, Fox-Turnbull, Granshaw, Harwood, Miller, O'Sullivan & Patterson, 2013). Technology education has technology (as that which is or exists) as discernible entity and takes place when technology is taught by teachers (to learners). Technology as a subject refers to its inclusion as a component of the school curriculum (Ankiewicz, 2013b). This paper has the South African context as point of departure, however, some aspects, findings and conclusions may also be relevant to other contexts.

The research design that underpins this conceptual paper can be best describe as desktop research where the researcher firstly derived criteria from a systematic review of the literature on the philosophy of technology, to secondly critically analyse the intended CAPS for Technology in the senior phase.

A sound philosophy of technology can yield insights into technology curriculum development (De Vries, 2005) and subsequently to the evaluation of the intended curriculum as well. To answer the first research question the key aspects of Mitcham's philosophical framework for technology will be discussed now. These key aspects underpin the derived criteria to be applied as part of an evaluation of intended technology curricula. It is important to note that these criteria do not encompass all criteria for the evaluation of the intended technology curriculum.

1.2 A PHILOSOPHICAL FRAMEWORK OF TECHNOLOGY AND CRITERIA FOR CURRICULUM EVALUATION

1.2.1 Ontology

Technology as ontology is the first mode in which technology is manifested Mitcham (1994). Within their area of experience human beings are confronted with particular phenomena as discernible and identifiable entities or structures, which they may reflect on and may make the object of their analytical activity (Schoeman, 1983:3; Van Schalkwyk, 1996). Technology is such a phenomenon or onticity with the status of something that **is** or **exists** (Ankiewicz, 2013a; 2013b).

In people's conception of being or existence (Van der Walt, Dekker & Van der Walt, 1985) concerning technology, artefacts or material objects such as tools, machines and consumer products come to mind when the word 'technology' is mentioned. 'When people talk about technology today, they usually mean the products of modern engineering: computers, power plants, automobiles, nuclear weapons.' (Bellington, 1986; in Mitcham, 1994, p.161; Custer, 1995). Technology as object is the 'most immediate, not to say the simplest, mode in which technology is found manifested, and it can include all human fabricated material artefacts whose function depends on a specific materiality as such' (Mitcham, 1994, p.161).

From an ontological perspective technology reflects the following fundamental aspects or universal characteristics, namely that it is:

- a phenomenon unique to **humans;**
- employed by **using tools**;
- a way of human **form creation;**
- giving form to **nature;**
- for **human purposes**;
- to deliver a **product or process**;
- **being determined by world views** (Ankiewicz, 2013a; Van der Walt & Dekker, 1982; Van Schalkwyk, 1996).

All particular forms of technology should, however, possess the fundamental characteristics of technology as universal phenomenon, or else it would not be technology. Particular forms are characterised by particular participants, purposes, methods and directions; by the spirit of the times concerned and by a specific outlook on life and the world, characteristic of the particular circumstances (Van der Walt & Dekker, 1982; Van Schalkwyk, 1996).

According to the above fundamental characteristics, things that are produced by animals, such as bird nests, spider webs and beaver dams and which share certain characteristics with artefacts

(Mitcham, 1994), are not classified as technology because one of the fundamental characteristics of technology is that it is a human phenomenon (Mitcham, 1994). Without man there would have been no technology.

The philosophy of technology helps position the teaching of technology among other subjects (De Vries, 2005). Thus, when evaluating the intended technology curriculum it is important to ensure that the assumed technology is true to the ontology of technology, in other words that what is presented in technology classrooms is in fact technology and not something else, for example applied science (Ankiewicz, 2013a; Rauscher, 2012).

1.2.2 Epistemology

According to Mitcham (1994) 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. The epistemology of technology has its basis in theoretical reflections and more recently also in empirical studies (Broens & De Vries, 2003; Ropohl, 1997).

Technology as knowledge may be distinguished on the basis of various types of knowledge, for example maxims, rules and theories (Mitcham, 1994). Although a distinction is made between conceptual knowledge ('knowing that') and procedural knowledge ('knowing how') in technology (McCormick, 1997; Ropohl, 1997; Ryle, 1949), these two types of knowledge cannot be separated (McCormick, 1997).

Conceptual or descriptive knowledge (the substantive nature of technology) refers to the links between knowledge items, to such an extent that when learners can identify these links, it is said that they show conceptual understanding. "Thus in the area of 'gearing' we hope that students will see the relationships among the 'direction of rotation', 'change of speed', and 'torque'' (McCormick, 1997, p.143). Conceptual knowledge that can be regarded as knowledge of devices or systems (Gott, 1988; in McCormick, 1997) 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 (the syntactical nature of technology) 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). Unlike conceptual knowledge, procedural knowledge cannot be taught in the true sense of the word: 'Technical know-how can be gained by thorough practice only' (Ropohl, 1997, p.69). Subsequently, technology curricula should accommodate technological procedural knowledge in such a way that learners are accorded sufficient opportunities for practice (Ankiewicz, 2013a).

It follows from the epistemology and methodology of technology that it is imperative to ensure that both conceptual knowledge and procedural knowledge are included in technology curricula. One type of knowledge must not be overemphasised at the expense of the other. In fact, it is of vital importance that the relationship between the two types of knowledge be acknowledged. If the point of departure in the technology curriculum is procedural knowledge which is acquired mainly by way of practising, and the technology that is supposed to be presented as phenomenon is ontologically justified, it will necessarily be contextualised by involving conceptual knowledge, of which the main themes are structures, control systems and the processing of materials (Ankiewicz, 2013a).

The content of technology curricula cannot unilaterally include conceptual knowledge of technology as artefacts, but should also contain procedural knowledge on how to design and make such artefacts, and vice versa (Ankiewicz, 2013a): '… 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).

Technology education should in its deepest essence also be activity-based, because '… (learner) activity is that pivotal event in which knowledge and volition unite to bring artefacts into existence …' (Ankiewicz, 2013a, p.6). Subsequently, technology curricula should accommodate technological procedural knowledge in such a way that it accords learners ample opportunities to practise it.

1.2.3 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).

Epistemology usually includes methodology (Van der Walt, Dekker & Van der Walt, 1985), which in particular provides insight into procedural knowledge in technology. Design processes constitute the object studied in the discipline of design methodology (De Vries, 2001), and two different paradigms, namely the rational problem-solving and the reflective practice paradigm form the basis of design methodology (Ankiewicz, 2013a; Ankiewicz, 2013b; Ankiewicz, De Swardt & De Vries, 2006).

Various kinds of complex thinking processes (creative and critical thinking, decision-making and problem-solving) underpin and form part of technological activities (Ankiewicz & De Swardt, 2002; De Swardt, 1998; De Swardt, Ankiewicz & Gross, 2010; Jakovljevic, 2002; Jakovljevic, Ankiewicz, De Swardt & Gross, 2004; Johnson, 1997; Reddy, Ankiewicz, De Swardt & Gross, 2003; Sharpe, 1996; Van Niekerk, Ankiewicz & De Swardt, 2010). Technology can therefore be regarded as both 'minds-on' (complex thinking) and 'hands-on' (practical activities) (McCormick & Davidson, 1996).

Two radically different paradigms form the basis of the discipline of design methodology (Dorst, 1997):

- 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 engineering.
- The reflective practice paradigm (as proposed by Schön [1983]) which shifts 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 architecture (Dorst, 1997).

Dorst (1997) distinguishes three phases during the design activity, namely the conceptual phase, the information phase and the embodiment phase. All three phases may 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 such a design project most of the design activities involve objective interpretation and are therefore better described by the rational problem-solving paradigm (Dorst, 1997).

Technological procedural knowledge is not only associated with technical skills but also with thinking processes and skills (McCormick, 1997). 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. Some of these thinking processes also form the core of aspects such as innovation and entrepreneurial attitude and behaviour associated with technology as volition. Conradie (1996) contends that creativity (innovation) is therefore a prerequisite and a non-negotiable core element of entrepreneurial behaviour.

Based on the paradigm of rational problem-solving a stage model may be used to provide learners the opportunity to develop procedural knowledge (which by definition may be tacit) through practice and which may serve as explicit organisational framework for the teacher and learner (Mawson, 2003; McCormick, 1997; McCormick, Murphy & Hennessy, 1994). It is common in technology education to present the procedural knowledge of technology in a stage-oriented format in models (Ankiewicz, De Swardt & Stark, 2000; De Swardt, Ankiewicz & Gross, 2010; GDE & GICD, 1999; Johnsey, 1995; Jones, 1997; Van Niekerk, Ankiewicz & De Swardt, 2010. Most models of the technological process indicate a linear progress, assuming that the process is completed in a particular sequence (Johnsey, 1995; Mawson, 2003).

One does, however, also find models with iterative design activities in the form of a loop (Garratt, 1998; Johnsey, 1995; Mawson, 2003; Todd, 1990). Each stage of the technological process requires of learners to apply some of the sub-processes of complex thinking (Ankiewicz & De Swardt, 2002). 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' (Mawson, 2003; McCormick, 1997, p.151).

From a design methodology perspective it has also became clear that the conceptual phase of a design project may be described more effectively by the reflective paradigm (Dorst, 1997) and learners should therefore also be provided with opportunities for reflective design. It is thus clear, from a methodological perspective, that thinking and intellectual skills development should receive more emphasis in the technology curriculum (Ankiewicz, 2013a).

1.2.4 Volition

The fourth mode in which technology is manifested is technology as volition (Mitcham, 1994), which is the most complex manifestation to grasp (Custer, 1995). Technology as volition is the result of the volition of the practitioner involved (Mitcham, 1994).

Technologies are associated with a wide array of volitional activities, drives, motivation, aspiration, intentions and choice. The phrase 'the will to …' is found in various definitions of technology (Ankiewicz, 2013b; Mitcham, 1994). To consider technology as volition points toward the need for an ethical analysis of technology (Mitcham, 1994). It will be necessary to also focus on technology as volition by considering ethical aspects regarding technology and its volitional characteristics.

According to Custer (1995) it is more correct to refer to the volitional characteristics such as drive, impact, conscious choice and free will of technology rather than stating that it manifests itself as volitional behaviour (Mitcham, 1994). There is a recurring tendency to think about technology in terms of its impact on entities outside of its essential nature, such as the impact of technology on the environment and society, and also the impact of human values and needs on technology (Custer, 1995).

It has already been mentioned that some of the complex thinking processes also form the core of aspects such as innovation, entrepreneurial attitude and behaviour associated with technology as volition. It is important, however, not to include technology as volition in isolation into the curriculum, but to integrate it with the previously discussed manifestations of technology, as technology has a human origin. It must not be forgotten that it is man who possesses particular technological conceptual and procedural knowledge and who needs to expand on and further develop these (Ankiewicz, 2013a).

With regard to the question on the extent to which the CAPS for Technology in the senior phase is aligned with the mentioned criteria for curriculum evaluation, it is important to note that this evaluation is limited to the extent of the alignment of the CAPS with the criteria, without necessarily making a final evaluation regarding the relevancy and efficiency of the CAPS.

1.3 FINDINGS

1.3.1 Ontology

According to the CAPS 'technology can be defined as the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration' (DoBE, 2011, p.9). This definition is in line with the universal characteristics of technology. However, the CAPS does not explicitly emphasise all of these characteristics under the content, concepts and skills to be taught to learners. Only a few aspects are touched upon briefly in the first week of Grade 7, term 1 (DoBE, 2011), namely who does technology in the world of work?; who is it for?; what is it for?; will it do the job? (human purposes), as indicated in Figure 1.

CHAPTER 3: CURRICULUM STATEMENT	GRADE 7	TERM 1
It is compulsory to cover the given scope in the term indicated. The sequence of the work within the term must be adhered to. Skills – investigating, drawing, designing, making and presenting – should improve progressively from term to term.		

Hrs	Focus	Content, concepts and skills / Enabling Tasks
Enabling tasks – build the capability to complete the formal assessment tasks later in the term		
2	**Design process skills**	• **Introduction: What is Technology?** • **Definition** **Scope** – who does Technology in the 'world of work'? • **How we will be working – the development of a technology task:** ♦ **Investigate**: find, use and acknowledge information. ♦ **Design**: design brief, specifications, constraints; initial idea sketches; choosing the best design; selecting materials. ♦ **Make**: draw plans; develop the manufacturing sequence; make the item/model. ♦ **Evaluate**: learners evaluate both their design stages and their final product. ♦ **Communicate**: learners present their solutions; learners compile all notes and drawings into a project report in their workbooks. **Design considerations** • **Fitness-for-purpose**: Who is it for? What is it for? Will it do the job? Is it cost effective? Is it safe? Is it easy to use (ergonomics)? Does it look good (aesthetics)? Will it affect society?

Figure 1: The universal characteristics of technology in the CAPS

There are also examples (i.e. Grade 8, term 4) where the content, concepts and skills included in the CAPS relate more to the natural sciences than to technology (refer to Figure 2). We need to acknowledge that there are particular knowledge aspects in the other subjects supporting technology that do not belong to technology. It would thus be unnecessary to reteach this content in technology.

FORMAL ASSESSMENT TASK 4: Mini-PAT Context: Will be given by materials developers		TOPIC: Electrical Systems and Control CONTENT: Logic Gates [70%]
Scenario: EITHER Crime is a problem facing every community in South Africa. Criminals invade homes especially where women, children or the elderly are often vulnerable and defenceless. Armed response companies can be summoned to the scene by alarms triggered by panic buttons placed strategically in the house. Learners must find out about AND & OR logic gates and select the appropriate logic for wiring a panic button. ***OR*** Any other relevant context involving logic gates, e.g. vending machines, etc.		
2	**Design skills** **Investigation skills**	• **Practical**: learners draw circuit diagrams AND connect circuits showing the effect of circuits with resistors connected in series and parallel. • **Investigation**: introduce Ohm's Law (*qualitatively – no calculations*). Learners use one cell, then two cells, and then three cells connected in series and note the effect on the brightness of a lamp. They must conclude that more cells in series (*more voltage*) will cause the *current strength* to increase, if the *resistance* does not change.

Figure 2: Ohm's law as natural science contents

1.3.2 Epistemology

Reference to the four content areas (structures, processing, mechanical systems and control, electrical systems and control) in the CAPS (DoBE, 2011) indicates conceptual knowledge. The CAPS states that: 'The **Design Process** (**I**nvestigate, **D**esign, **M**ake, **E**valuate, **C**ommunicate –

IDMEC) forms the backbone of the subject and should be used to structure the delivery of all learning aims. Learners should be exposed to a problem, need or opportunity as a starting point. They should then engage in a systematic process that allows them to develop solutions that solve problems, rectify design issues and safety needs' (DoBE, 2011, p.11). This implies that both procedural knowledge and the rational problem-solving paradigm are taken as point of departure for the curriculum. However, the way in which the curriculum is structured indicates that conceptual knowledge (factual knowledge, embedded in conceptual knowledge/'knowing that') and knowledge of basic technological skills (as lower-order procedural knowledge/'knowing how'), which are introduced in a fragmented way, actually form the point of departure, as reflected in Figure 3. The reason for the fragmentation probably lies in the requirement that 'Where possible in the senior phase, the learner should engage in projects that integrate processing, structures and systems and control' (DoBE, 2011, p.10).

CURRICULUM STATEMENT		GRADE 8	TERM 1
It is compulsory to cover the given scope in the term indicated. The sequence of the work within the term must be adhered to. Skills – investigating, drawing, designing, making and presenting should improve progressively from term to term.			
Hrs	**Focus**	**Content, concepts and skills**	**Enabling Tasks**

2	**Structures**
	
	Investigation skills
		Frame structures
		▪ Definition of *frame* structures.
		  ▪ Purpose of structural members (components) in wood and steel roof trusses (king and queen post, strut, tie, rafter, tie beam).
		  ▪ Learners identify structural members and type of force (shear, torsion, tension, compression) acting on them in given frame structures.
		▪ **Case study**: Electrical pylons – use pictures of a range of pylon designs noting:
		  ▪ The variety of designs that solve the same problem effectively.
		  ▪ The use of *internal* cross-bracing and triangulation to provide stiffness.
		▪ Structural members under tension/compression (worksheet).	

2	**Structures**	**Structural members**
		▪ Structures that span over space:
		  ▪ Beams: steel I-beams (girders), concrete lintels; beam and column bridge.
		  ▪ Alternative bridge supports: suspension bridges; cable-stayed bridges.
		  ▪ Arches: arches in buildings, bridges, dam walls.
		  ▪ Cantilevers: simple cantilever, cable-stayed cantilever.
		Structural failure – the three most likely ways structures fail are:
		  ▪ **Fracture** of a member – due to lack of strength.
		  ▪ **Bending** (flexing, buckling) – due to lack of stiffness (rigidity).
		  ▪ **Toppling over** – due to lack of stability (top heavy, narrow base).	

4	**Communication skills**	▪ **Purpose of graphics**: develop and communicate ideas.
		▪ **Conventions**: outlines (thick/dark); construction lines (thin/feint); hidden detail (dashed); centre lines (chain dash-dot); scaling up and scaling down; dimensioning (in mm).
		▪ **Working drawing** techniques for planning:
		  ▪ Single view flat 2D drawing with dimensions, line types and scale.
		  ▪ Isometric – using underlying isometric grid (term 1) and simple instruments (term 3).
		▪ **Artistic drawing**: Double vanishing point perspective with colour, texture and shading.
		  ▪ Sketching – using pencil, ruler and blank paper.
		  ▪ Enhancing drawing to promote realism using colour, texture, shading and shadows.	

4	**Mechanical systems and control**
	
	Investigation skills
	
	Communication skills
		▪ **Revision**: mechanical advantage. Well-designed machines give "*mechanical advantage*".
		▪ All complex machinery consists of combinations of simple mechanisms.
		  ▪ **The wedge**: e.g. inclined plane or ramp, door wedge, knife blade, etc.
		  ▪ **The wheel and axle**: e.g. from bicycle to shopping trolley.
		▪ **Gears**: (wheels with wedges for teeth)
		  ▪ Show how meshing of two spur gears causes **counter-rotation**.
		  ▪ Show how introducing an **idler** gear between two spur gears synchronises rotation of the driver and driven gears. **Note**: Since a small idler will rotate more times than the larger gears, it should be made of harder material.
		  ▪ Gear ratios:
		Show how different sized gears result in a change in the velocity ratio as well as an 'opposite' change in the force ratio – *if force increases, speed decreases, and vice versa.*
		▪ Mechanisms that change the direction of movement:
		  ▪ **The Cam**: show how a cam converts rotary motion into reciprocating motion. Compare an eccentric wheel and a snail cam.
		  ▪ **The Crank**: an adaptation of a second-class lever. Show how a crank converts rotary motion into reciprocating motion.
		▪ **Graphic skills**: learners draw an artist's impression of one of each of the above mechanisms in their books using colour, shading and texture.	

Figure 3: Conceptual knowledge (on structures and mechanisms) and lower-order procedural knowledge (knowledge on communication and investigation) introduced in a fragmented way in the CAPS

This is also confirmed by the following statement 'The recommended approach will be to introduce the required knowledge followed by **practical** work in which the knowledge is applied' (DoBE, 2011, p.10) as indicated in Figure 4.

FORMAL ASSESSMENT TASK 1: Mini-PAT CONTEXT: To be provided by material developers		TOPIC: Structures / Mechanical Systems and Control CONTENT: Frame structures with mechanisms [70%]
7	Structures Evaluation skills Design skills Making skills Communication skills	Learners work in teams to design and make a structure utilising required structural components and mechanisms to suit the context provided. ▪ Evaluate: learners examine information on several complex structures and list advantages and disadvantages in the designs. ▪ Design: initial idea sketches. ▪ Design: design brief with specifications and constraints. ▪ Make: a 3D isometric projection of the idea with dimensions and drawn to scale. ▪ Make: a working drawing in 2D showing one view with dimensions and line types. ▪ Make: teams build their structure housing mechanisms using safe working practices. ▪ Communicate: teams present their plans and model. ▪ Communicate: a sketch in double VP perspective enhanced using two of colour, texture or shading.
1	Formal Assessment Task:	Test (the test may be before or after the mini-PAT) [30%]
Formal Assessment: Term 1:		Weighting: 10% of promotion mark Mini-PAT: [70%] Test: [30%] Total: 100%

Figure 4: Procedural knowledge introduced by a Mini-PAT after acquiring conceptual knowledge

This might lead to the separation of conceptual and procedural knowledge instead of integrating the two types of knowledge. There appears to be more emphasis on conceptual knowledge than procedural knowledge, without sufficiently emphasising the close relationship between the two. This is contrary to the way in which technologists work (design methodology). Technologists do not gain the required conceptual knowledge in a fragmented way beforehand, but rather in an integrated way during the design process – thus procedural knowledge. Johnson (1997) points out that for various reasons knowledge and skills are not easily transferred (Rauscher, 2012). One can thus expect that learners will probably struggle and may lose perspective of the whole. The procedural knowledge is however imported in the so-called MiniPAT at the end of the term. The relationship between conceptual and procedural knowledge is indicated in the MiniPAT, as shown in Table 1.

Table 1: The relationship between conceptual and procedural knowledge in the MiniPATs (DoBE, 2011)

Grade	Term	Topic (Specific aim 2 – conceptual knowledge)	Context (Specific aim 3)	Time duration
7	1	Mechanical systems and control (Content: levers, linkages, hydraulics, pneumatics)	Jaws-of-life rescue system; impact of technology	2½ weeks, 7 hours
	2	Structures (Content: Frame structures)	Cell phone tower; impact of technology	4 weeks, 8 hours
	3	Electrical systems and control/structures/mechanisms (Content: Structures and electricity/cranks and pulleys)	Crane with an electromagnet; recycling and impact	5½ weeks, 11 hours
	4	Processing/bias in and impact of technology (Content: Properties of materials)	Shelters for refugees	3 weeks, 6 hours
8	1	Structures/mechanical systems and control (Content: Frame structures with mechanisms)	To be provided by material developers	3½ weeks, 7 hours
	2	Impact of technology/ processing/structures (Content: Counteracting effects of negative technology)	To be provided by material developers	5 weeks, 10 hours
	3	Structures/mechanical systems and control (Content: a structure with a mechanism lifting a load)	Tender for contracts, shaft head-gear for a mine, budget, tender	4 weeks, 8 hours
	4	Electrical systems and control (Content: Logic gates)	To be provided by material developers	3 weeks, 6 hours
9	1	Structures (Content: Identifying a problem within a given scenario)	Community issues: solving the problem of a community living on the far side of	6 weeks, 12 hours

		the river, budget based on real costs	
2	Integrated systems – Mechanical/electrical/ hydraulics, pneumatics (Content: Problem solving/ mechanical advantage)	To be provided by material developers	3½ weeks, 7 hours
3	Innovation: Electronic systems and control	Assemble and connect the components of a given circuit	4 weeks, 8 hours
4	Materials processing (plastics)	Re-use, reduce, recycle	4 weeks, 8 hours

It was mentioned earlier that technology education should by its deepest essence also be activity-based, and that learners should be accorded sufficient opportunities to practise technology. Hence, the limited time allowed in the CAPS for the acquirement of procedural knowledge (in the mini-PATs) is a concern.

1.3.3 Methodology

In the CAPS purpose (DoBE, 2011, p.9) it is mentioned: 'The subject stimulates learners to be innovative and develops their creative and critical thinking skills.' It is also stated, amongst others, that 'Technology will teach (sic) learners the opportunity to learn: To use a variety of life skills in authentic contexts (such as decision making, critical and creative thinking, cooperation, problem solving and needs identification)' (DoBE, 2011, p.10). There is no reference in the intended Technology curriculum for the senior phase to decision-making and design as sub-processes of complex thinking. The intended curriculum also does not provide for explicit teaching of such thinking skills as so-called enabling tasks before learners are expected to apply these. Learners are thus thrown in at the deep end when during the MiniPATs the focus is on the design process, which leans heavily on complex thinking processes and skills.

The CAPS states that: 'The **Design Process** (**I**nvestigate, **D**esign, **M**ake, **E**valuate, **C**ommunicate – **IDMEC**) forms the backbone of the subject and should be used to structure the delivery of all learning aims. Learners should be exposed to a problem, need or opportunity as a starting point. They should then engage in a systematic process that allows them to develop solutions that solve problems, rectify design issues and safety needs' (DoBE, 2011, p.11).

The systematic process with which learners need to engage implies that the rational problem-solving paradigm is taken as point of departure. The definition of 'Investigation' refers to:

‘While investigating, learners should be provided with opportunities to explore values and attitudes and develop informed opinions that can help them to make compromises and value judgements. Investigation can happen at any point in the Design Process. It should not be seen as something that must be completed before design begins’ (DoBE, 2011, p.10). Mentioning that it may occur at any point, probably indicates to some extent an iterative rather than a linear process, although it is not possible for only a single stage to be iterative. The reference to ‘... opportunities to explore values and attitudes and develop informed opinions that can help them to make compromises and value judgements’ touches on volition, and indicates that technology should be presented in an integrated way with the other manifestations.

It has already been mentioned that the rational problem-solving paradigm seems to have been taken as point of departure. There is no reference to the reflective paradigm, in which learners may design more freely and in a less structured way, during the conceptual phase of the design.

1.3.4 Volition

It has already been mentioned that the curriculum makes no provision for the direct teaching of thinking skills that form the core of aspects such as innovation, entrepreneurial attitude and behaviour associated with technology as volition, as so-called enabling tasks before learners are expected to apply these.

It has already been mentioned that thinking about technology according to its impact on entities stretching outside its essential nature is frequently found: as the impact of technology on the environment and society, and also the impact of human values and needs on technology (Custer, 1995). The strong emphasis on the impact of technology is also very immanent in the CAPS (refer to Table 2).

Table 2: Emphasis on the impact of technology in the CAPS (DoBE, 2011)

Grade	Term	Focus (on Specific aim 3)
7	1	Impact of technology
	2	Impact of technology
	3	Impact of and bias in technology
	4	Impact of technology/indigenous technology
8	1	
	2	Impact of technology (positive and negative)
	3	Impact of technology/indigenous technology/ gender bias
	4	Impact of and bias in technology

9	1	
	2	
	3	
	4	Impact of technology/indigenous technology

1.4 DISCUSSION AND CONCLUSION

In answering the first research question it is important to point out that curriculum developers should ensure that they take note of the philosophical framework for technology, based on the four modes of the manifestation of technology, namely as object (ontology), knowledge (epistemology), activity (methodology) and volition, as these are directives for curriculum development and evaluation. The set of criteria that has been derived from these manifestations could be used for this purpose.

The second research question may be answered by stating that a requirement for education and curriculum policy is that it should be formulated comprehensively in order to accommodate the philosophy of a specific subject. In order to be relevant, the technology curriculum should be based on the four modes of the manifestation of technology (De Vries, 2003b; Mitcham, 1994). In spite of the shortcomings pointed out and discussed earlier, it is apparent that the CAPS does to a large extent accommodate the philosophy of technology, and that it is based on four modes of the manifestation of technology.

The **specific aims** must embrace the philosophy of technology with reference to the four ways in which technology is manifested (ontology, epistemology, methodology and volition) (Ankiewicz, 2013a). The way in which the technology curriculum for the senior phase in South Africa has been compiled, is in line with the philosophical framework. Specific aim 1 (SA 1), for example, focuses on technological procedural knowledge; specific aim 2 (SA 2) focuses on technological conceptual knowledge and specific aim 3 (SA 3) on technology as volition.

Specific aims cannot be achieved in a vacuum, and therefore learning content (as included in the epistemology and methodology) is the tool for learners to attain the aims (Ankiewicz, 2013a) : '… when you consider the content that you will use to help learners achieve the outcomes ...' (Killen, 2000, p.xiv).Traditionally three types of content are included in curricula, namely knowledge, skills (not only psychomotor but also cognitive skills) and attitudes/the affective. **Knowledge as content** should be guided primarily by the epistemology, without disregarding the other aspects. **Skills as content** should be directed mainly by methodology and the **affective as content** by volition. Although the content of technology may 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, 2013a; Ankiewicz, Van Rensburg & Myburgh, 2001, p.95).

Knowledge as content in the CAPS is in agreement with the epistemology of technology to a reasonable extent. The CAPS falls short mainly regarding the promotion of thinking processes and thinking skills, as these are not explicitly included as part of the methodology of technology. It is possible that these may be achieved via the experienced and hidden curriculum. The CAPS over-emphasises the impact of technology (the affective as content), possibly at the expense of aspects such as innovation, which is underpinned by thinking skills.

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