The question of Technology Education: A pertinent issue

Inaugural Lecture

25 February 2016

Professor Mishack T Gumbo

University of South Africa

College of Education

Department of Science and Technology Education

1. Introduction

Acting Vice Principal, Ms Liana Griesel, Executive Dean of the College of Education, Professor Veronica McKay, Chair of the Department of Science and Technology, Professor Nkopodi Nkopodi, my family, colleagues and friends, greetings. This auspicious celebration about my full professorial title marks one of my milestones in my academic career which I will cherish for years to come. I am addressing you on the title: The Question of Technology Education: A Pertinent Issue

Let us consider the following two quotes:

> Everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it. But we are delivered over to it in the worst possible way when we regard it as something neutral … [which] makes us utterly blind to the essence of technology (Heidegger 1977:1).
>
> The task of defining technology has been an unhappy history (Rooney 1995:1).

These quotes create the need to define Technology and Technology Education. In South Africa, the question of what Technology Education is and what it is not is pertinent for a number of reasons apart from the fact that it is an under researched area. Technology Education as a subject is a relative newcomer to the school curriculum (Gumbo 2003; Kalanda 2005; Maluleka, Wilkinson & Gumbo 2006; Mapotse & Gumbo 2013; Stevens 2005). As a result of the subject's relative newness, it has little or no established history, something that has contributed to the misunderstandings, misinterpretations and misrepresentations of what it really is (McCormick 1997). This is referred to in other literature as 'confusion' (Daugherty & Wicklein 2000; Pudi 2007; Dugger 2008).

According to the Indiana Technology Education Curriculum Standards (2006:3), technology is "widely misunderstood, misdefined and distrusted". Therefore, defining Technology Education would help to clear up the confusion about the speciality and scholarship in the field. I therefore hope that at the end of this lecture you will understand me as a Technology Education scholar and not as an Educational Technology scholar or a Science Education scholar. I am saying this because people do not understand what Technology Education is and what it is all about; thus sending everything technological to us Technology Education lecturers or linking it to us. My department, namely, the Department of Science and Technology Education, has four units: Natural Science Education, Technology Education, Computer Integrated Education (CIE) (Information and Communication Technology) and Environmental Education. However, people tend to confuse my Unit and the CIE Unit. Added to this confusion is the fact that a Google search using the term ‘Technology Education’ always produces literature on Educational Technology and just one or two hits for Technology Education per se. So, you need to be a Technology Education specialist in order to know what other strategies to use to access relevant literature on Technology Education.

Furthermore, the popular media tend to use the terms ‘science’ and ‘technology’ interchangeably or as one homogeneous phrase (Davies 1997:102), or even the term ‘technoscience’, or the phrase ‘technology as science’. We are Technology Education lecturers, not Natural Science Education lecturers; we are rather companions to Natural Science Education lecturers because of the complementary nature of Technology Education and Science Education. The confusion about Technology Education is also compounded by the fact that, at its inception as part of Curriculum 2005 in 1998, there were no trained Technology Education teachers (Gumbo, Makgato & Muller 2012; Mapotse & Gumbo 2013). This resulted in teachers qualified in other subjects, such as Science Education and Consumer Studies, being asked to teach Technology and only later were they trained through workshops as Technology Education teachers and/or enrolled for programmes in Technology Education. Even the currently trained Technology Education teachers struggle both with the teaching and the content knowledge of the subject (Mapotse 2012). Garson (2000) declares in this regard that, based on Technology Education’s relative newness, teachers in the field are still grappling with understanding what it actually means.

As yet, very few Technology Education teachers possess a Technology Education qualification at a level that qualifies them to enrol in a master’s of doctoral programme. This compels Technology Education lecturers to supervise in their secondary fields of specialisation. Moreover, the attempt to scrap Technology Education from the curriculum during the two curriculum reviews of 2000 and 2009 (Department of Education 2000; Chisholm 2003; Gumbo 2013) has dampened the keenness to know more about Technology and Technology Education.

Some research adds to the confusion by misinforming the readership about the meaning of Technology Education. I came across the most striking misconception of Technology Education in a recently published study titled *How is Technology Education implemented in South African schools? Views from Technology Education learners* by Nokwali, Mammen and Maphosa (2015). These authors are academics based at two universities in South Africa. The content of their article runs incongruent to the title. The content is purely about technology integration in teaching (Educational Technology), not Technology Education. Ironically, the headings of sections in the article are based on Technology Education despite the fact that their respective content says otherwise. To buttress this point about the subject of Technology Education being blown off direction completely, the authors’ very first sentence in the introduction is a quote from an Information and Communication Technology (ICT) related source: “The use of technology in education is becoming an increasingly important part of higher and professional education”. The introduction ends with a paragraph that quotes a source from the field of Technology Education, which states: “The literature on technology abounds with misrepresentations and stereotypical perceptions of technology and TE”. The authors seem to be the victims of this statement. The contribution of their study is not stated at all; I would suggest that it actually contributes to the very literature which misrepresents and is stereotypical about Technology and Technology Education. The section on "Challenges in TE Curriculum Implementation" is misleading indeed, evidenced in a cited survey of 612 English primary school learners' perceptions on children's engagement with ICT inside and outside the school context (Nokwali et al 2015:563). The items in the survey questionnaire used in the study (Table 2 in Nokwali et al 2015:568) seem to relate to Technology Education, but a careful expert in Technology Education would easily spot the fact that the accompanying description of the findings is purely about ICT, not about Technology Education. Of the 48 quoted sources in the article, only nine are in the field of Technology Education and even then misinterpreted and misapplied in the article. Twenty-nine of the sources are in ICT. I suspect the article fell into the hands of reviewers who are not experts in Technology Education, who in their ignorance recommended it for publication.

The relative newness of Technology Education is a reflection of the global reality. Elsewhere there is also a struggle to understand the subject, a struggle which results from a misunderstanding of the term *technology* itself. For instance, Dugger (2008) reports two interview-based surveys that were conducted in 2001 and 2004 with American men and women of 18 years and older about what Americans think technology actually is. The results of the survey, according to Dugger (2008:1–2), are as follows:

- Science and technology are basically one and the same thing (59% in 2001 and 62% in 2004);
- Narrow view of technology as being computers, electronic and internet (67% in 2001 and 68% in 2004);
- It is very or somewhat important for high school students to understand the relationship between science and technology (98% in 2001); and
- Schools should include the study of technology in their curriculum (97% in 2001 and 98% in 2004).

This related issue about the understanding of Technology Education therefore raises a pertinent question: What is Technology Education? It is important to address this question because the confusion created affects even the implementation of Technology Education (Daugherty & Wicklein 2000) and its content (Williams 1996). Answering this question will also clarify exactly what my colleagues and I are doing in the subject.

In response to the question of Technology Education, I want to start by explaining what Technology Education is not. Then I entertain discourses on the definitions of Technology Education and Technology, including the dimensions of Technology. These discourses include a piece on the indigenous perspective of Technology Education. Scholars who attempt to define Technology Education are silent on this aspect. This lecture accordingly contributes to this perspective. However, I should caution that the treatment of the indigenous perspective in this lecture as a separate entity does not suggest coming up with a separate content for Technology Education on indigenous technology, nor does it suggest teaching an indigenous perspective in parallel to the conventional perspective – I vie for a dual-integrated approach in a manner similar to the model that Yishak and Gumbo (2015) have suggested (it is not within the scope of this lecture to discuss the details of the model). Finally, I propose a Technology Education Definitional Framework which should guide future attempts to define Technology Education.

2. Technology Education is not Science Education, Educational Technology or Technical Vocational Education

2.1 Technology Education is not Science Education

Technology and science have grown so close together that the blurred line between the two adds to the mistake of regarding technology simply as science. This misconception adds to the thinking that Technology Education teachers or learners are doing science. I want to acknowledge the similarities that technology and science enjoy, but most importantly talk about their differences. To explain the differences between the two helps to facilitate the understanding of Technology Education. Technology shares some aspects with science, as it does with other fields that lie close to it, such as Engineering and Mathematics. The obvious feature of this synergy lies in Electricity and Electronics – both Technology Education learners and Science Education learners should understand how circuit boards work even though for different educational purposes. However, according to Li-Hua (2009:18), to limit technology to these subject fields loses sight of other supporting technologies. For example, there is a body of knowledge that also comes from the Consumer, Entrepreneurship and Environmental subject fields. In Entrepreneurship, for instance, the design, manufacturing and marketing of a certain product involves much technology. In short, almost every subject shares a component with Technology Education. So, we should explore the comparisons between technology and science bearing in mind the fact that there are bodies of knowledge that feed into technology. For the purposes of my lecture, I focus on science only for the reason given in the introduction; that Technology Education is misconstrued as Science Education. The two are different and as subjects are independent of each other. The differences that exist between the two are depicted in table 1, sourced from Chant (1989), Fraser (1996), Herschbach (2001), McCormick, Murphy and Harrison (1994) and Schuurman (1995).

Table 1: Technology versus Science

Technology	**Science**
The *aim* is to design new products that did not exist before and create successful artefacts and systems to meet people's wants and needs.	The *aim* is to explore existing phenomena (technologies) to reach new knowledge and pursue understanding for its own sake.
Criteria: solutions should be effective, efficient, within acceptable tolerances.	*Criteria*: truth, accuracy, the ideal.
Need-/want-driven.	Curiosity-driven.
Works in the *real* complex world – it stresses instrumentation and application.	Works with an *idealised* and simplified world – it values the abstract and the general.
Creative.	Reflective.
Focuses on what might be.	Focuses on what is.
Looks for solutions that are optimal for a specific situation.	Looks for uniform knowledge that applies everywhere in the same way.
Design, invention, production; design is a fundamental activity.	Discovery (mainly by controlled experimentation); research is a fundamental activity.
Analysis and synthesis of designs.	Analysis, generalisation and the creation of theories.
Holism, involving the integration of many competing demands, theories, data and ideas.	Reductionism, involving the isolation and definition of distinct concepts.
Activities are always value-driven.	Making virtually value-free statements.
Concentrates on the made environment.	Concentrates on the natural environment.
Search for and theorising about the new processes (e.g. control, information, circuit theories).	Search for and theorising about causes (e.g. gravity, electromagnetism).

Technology	Science
Pursuit of sufficient accuracy in modelling to achieve success.	Pursuit of accuracy in modelling.
Taking good decisions based on incomplete data and approximate models.	Drawing correct conclusions based on good theories and accurate data.
Design, construction, testing, planning, quality assurance, problem solving, decision-making, interpersonal and communication skills.	Experimental and logical skills.
Trying to ensure, by subsequent action, that even poor decisions turn out to be successful.	Using predictions that turn out to be incorrect to falsify or improve the theories or data on which they were based.

Sparkes (in Davies 1997:104) tabulates the key activities which apply to technology and those that apply to science. These are mentioned in table 2.

Table 2: Focus of key activities between technology and science

Key activities in Technology	Key activities in Science
Successful products	Explanation and prediction
Invention	Discoveries
Theorising about processes	Theories about issues
Design	Analysis
Holism	Reductionalism
Search for solutions	Search for causes
Study and research for pursuit of only as much accuracy as is necessary for success	Study and research for its own sake
Reaching good decisions based on incomplete data	Reaching correct conclusions

The scholarly discourses that entertain differences between technology and science have led to five views on the two. These views help facilitate the understanding of the differences and complimentarity between technology and science as they have implications for the teaching of Technology. These views are given according to Gardner (in Davies 1997:102) with a critical reflection on each:

Technology as applied science (TAS) view

Technological capability grows out of scientific knowledge (widely held view). The historical nature of technology takes little or no account of science.

Criticism: Designers are open-minded about drawing in other knowledges from whatever source that would help them in their pursuance of solutions. Science has a tendency to depend heavily on technology both for ideas and apparatus. Galileo would most probably not have succeeded in developing a model of the solar system without the telescope with which he observed the moons of Jupiter (Davies 1997:107).

Demarcationist view

Science and technology are independent with differing goals, methods and outcomes.

Criticism: In the real world, it is almost unimaginable that technologists and scientists engage in different research and development projects. According to De Vries (during the 24th Conference of the Southern African Association of Mathematics, Science and Technology Education (SAARMSTE) held in Pretoria on 12–15 January 2016), looking only to the differences between technology and science denies us the opportunity to acknowledge the complementary nature that exists between them as well.

Materialist view

Technology precedes science; technology preceded science historically and ontologically – experience with tools, instruments and other artefacts is necessary for conceptual development.
Criticism: Too much emphasis of the materialistic nature of technology seems to overlook the fact that most of modern technology is deliberately scientific – informed by continual formal study and empirical investigation. Figure 1 demonstrates this convergence.

Interactionist view
Technology and science engage in a two-way interaction; scientists and technologists are groups of people who learn from each other in mutually beneficial ways. Again, figure 1 suggests this possibility.
Criticism: Theory and practice do not always make good bedfellows – many scientists claim higher status for their lofty conceptual frameworks compared to pragmatic engineers or designers who may dismiss the abstractness of Science.

Indistinguishable view
"Popular media tend to use the terms science and technology interchangeably, or as one homogeneous phrase" (Davies, 1997:102). The role played by technology and science in modern times in research and development dismisses the strict distinction between the two.
Criticism: Scientists feel that this view threatens their field because it waters down its purity. In line with the differences given in table 1, it is argued that the modes of thinking between these two have fundamental differences and thus blurring the line between them is misleading.

There is a tug of war about the differences between technology and science that is explained by scholarly discourses. During the development of the philosophy of Technology Education as a discipline there was a dominant view of Technology as Applied Science (De Vries 1996), that is, science was not only viewed as the predecessor, but progenitor of technology as well. This seems to have even contributed to the way teachers view technology, which misleads their understanding of the same. Gil-pe'rez, Vilches, Fernana'ndez, Cachapuz, Praia, Valde and Salinas (2005:309), in their study Technology as Applied Science: A serious misconception that reinforces distorted and impoverished views of science, asked the Science Education teachers what technology is. Almost without exception their answers indicated that Technology is Applied Science. This limited view could really hamper the teaching of Technology especially if taught by Science Education teachers who hold the view that scientific knowledge is the work of isolated great scientists, thus ignoring the role of cooperative work and of exchanges between different research teams (Gil-pe'rez et al 2005: 311), thus rendering science as an individualistic and elitist conception (Gil-pe'rez et al 2005: 311). This is contrary to Technology Education's encouragement of a collaborative approach with other fields. For example, technicians contribute to scientific-technological development (Gil-pe'rez et al 2005: 311). We need to remind ourselves of the steam engine which was invented by Newcomen and a blacksmith and a smelter, and which served to help kick-start the Industrial Revolution (Gil-pe'rez et al 2005:311). It is also argued that this technological development contributed to advancements in science (Gil-pe'rez et al 2005:311).

Consequently, current developments are opposed to the paradigm expressed in the phrase 'Technology is Applied Science' (De Vries 1996). This opposition is motivated by the differences that exist between these two, as indicated in tables 1 and 2, which represent the ideas of scholars who researched the differences between these two subject fields. In a school context, Science teaching in general happens mainly through the transmission of knowledge without real experimental work necessarily taking place (Gil-pe'rez et al 2005). As a former student of Science Education, I can recall that my class was not often required to perform experiments but rather to learn theory. In instances when Science Education involves experiments it needs technology, as will be explained shortly when I discuss the contribution that technology has made to science and vice versa. According to the Québec Education Program (2016:1), science, unlike technology, is a means of analysing the world around us with the aim of describing and explaining certain aspects of the universe. Science is premised on a set of theories, knowledge, observations and methods, and develops models which enable it to achieve this aim (also see Massachusetts Science and Technology/Engineering Curriculum Framework 2006:7).

Technology, on the other hand, is more pragmatic as it is more action-based to help humans to interact with the environment of which they form an integral part. The action-based nature of technology manifests in the technological fields of medicine, agriculture and agri-food, energy, information and communication, transportation, manufacturing and construction (Dugger & Naik 2001; Québec Education Program 2016:1). Technology covers "a wide variety of the most simple to the most sophisticated achievements such as techniques, processes, tools, machines and materials" (Québec Education Program 2016:1). As an action-based means, its core activity is anchored on the term *design*, that is, the design of technological solutions to problems/needs/wants while based on certain principles and concepts. However, it makes use of its own knowledge and practices and "its more pragmatic aspect leads to the development and use of more specific methods" (Québec Education Program 2016:1).

Then there is a chicken-and-egg issue about technology and science, which is about which one of the two came first. Here again there is an attempt to protect science by claiming its precedence and progenitorship over technology. *A Companion to the Philosophy of Technology* by Olsen, Pedersen and Hendricks (2009) entertains this idea. The contributors to this piece of work seem to oppose the idea that technological advancements preceded the scientific theories that explain them. They advance the idea that, chronologically, science existed before technology – the fruits of technology do not fall far from the science tree. For instance, one of these contributors, Heidegger (1977:6), claims that modern technology is based on modern physics because, according to him, mathematical physics arose almost two centuries before technology, namely, in the 17th century, while machine-powered technology got underway only when it could be supported by exact Physical Science. The chronological view locates modern Physical Science in the 17th century. Heidegger (1977:7) uses a few examples in an attempt to support his claim:

- Agriculture is now the mechanised food industry.
- Air is now set upon to yield nitrogen, the earth to yield ore, ore to yield uranium, for example; uranium is set to yield atomic energy, which can be released either for destruction or for peaceful use.
- The coal that has been hauled out in some mining district has not been supplied in order that it may simply be present in somewhere or other. It is stockpiled; that is, it is on call, ready to deliver the sun's warmth that is stored in it. The

sun's warmth is challenged forth for heat, which in turn is ordered to deliver steam whose pressure turns the wheels that keep a factory running.

- The hydroelectric plant is set into the current of the Rhine. It sets the Rhine to supplying its hydraulic pressure, which then sets going the electric current for which the long-distance power station and its network of cables are set up to dispatch electricity. In the context of the interlocking processes pertaining to the orderly disposition of electrical energy, even the Rhine itself appears as something at our command. The hydroelectric plant is not built into the Rhine, rather the river is dammed up into the power plant. The river is now a water power supplier, derived from out of the essence of the power station.

Then there is an opposing view to the chronological view, namely, the historical view, which claims that technology preceded science. However, there is little dedication to the discourse on this view. This suggests that more research is required into this aspect. Illustrations of the historical view (technology enjoys precedence over science) include, firstly, the compasses that have been in use since before the first modern study of magnetism. Secondly, the first engines operated without the benefit of a study of thermodynamics, just as the first airplanes flew without the help of aerodynamic theory. In such cases, technology provided extraordinary opportunities for the investigation and questioning that led to the development of the new theories.

But it is not all about the differences between technology and science that Technology Education teachers and learners should know about; the synergy that exists between these two should also be acknowledged. Adopting this kind of attitude to a comparison of technology and science helps not to take an impoverished view of technology and science. Technology and science are becoming increasingly interdependent and interfused; so much so that the line between them has become blurred (Davies 1997; Massachusetts Science and Technology/Engineering Curriculum Framework 2006). Figure 1 maps the convergence that brings this influence at the levels of inquiry into the problem, the solutions sought and the implied methods and results.

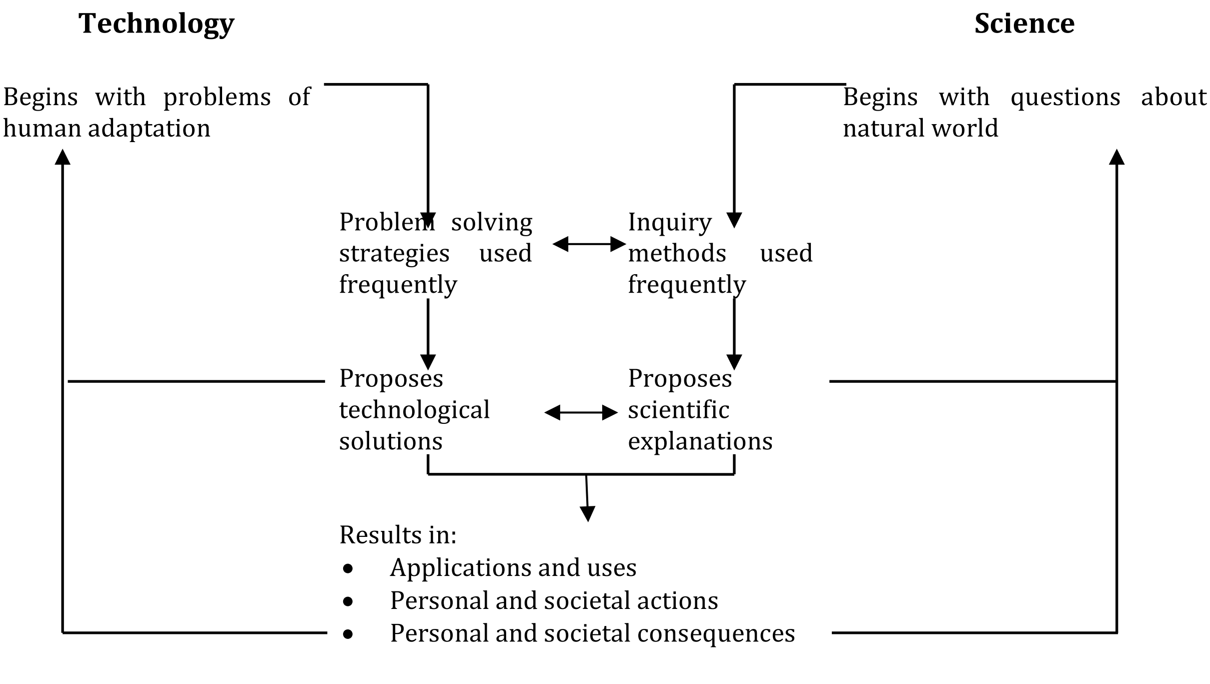


Figure 1: The model of Technology as it relates to scientific inquiry (adapted from the Atlantic Provinces Education Foundation 2001:6)

In its effort to understand the universe, especially in modern times, science draws from technological developments and achievements, for example to test a hypothesis in research that there is a need to conceive and construct experimental designs; this in itself is technological work – to solve the technological problems that humans encounter (Gil-pe'rez et al 2005:312). Conversely, technology develops a solution or meets a need/want by developing technical objects, systems, products or processes, and for that it uses scientific principles, laws and theories (Québec Education Program 2016). "We should bear in mind that research is an answer to problems that are often linked to human needs and so to the search for adequate solutions to previous technological problems" (Gil-pe'rez et al 2005:314). The complementarity of technology and science can also be seen in their respective practical and design approaches to the physical world (Québec Education Program 2016:2). In both cases, direct engagement with the problem is central to defining and solving it (Massachusetts Science and Technology/Engineering Curriculum Framework 2006:8).

So, this lecture teaches us that technology and science are not the same, so is teaching learners of these two subject fields. They differ in terms of their respective purposes and foci. It is important to understand technology in the light of these differences. But our lenses should also show us the complementary nature that exists between technology and science.

2.2 Technology Education is not Educational Technology

"There is much confusion today when attempting to understand the differences between technology education and educational technology" (Dugger & Naik 2001:31). Technology Education is a school subject alongside other subjects such as Mathematics, Setswana, Science, and so forth. It is a specialised subject taught by Technology Education teachers and learnt by Technology Education learners. Its aim is to make learners understand the concept of technology and ultimately to qualify them for different careers as engineers, artisans and suchlike. Educational Technology, which is sometimes referred to as Instructional Technology, is a specialised field which has to do with the technological resources which aid the teaching of subjects. Such technological resources can be used to facilitate teaching but their usage is not confined to the educational enterprise only. According to Dugger and Naik (2001) and Richey (2008), Educational Technology is the study of the facilitation of learning to make it meaningful to learners with the aim of improving their performance by creating, using and managing appropriate technological processes and resources. Thus, Educational Technology is about technology *in* education (Dugger & Naik 2001:32).

Educational Technology is meant to be used by all teachers of all subjects as a tool to facilitate and enhance teaching and learning – teaching and learning *with* or *through* the medium of technology. It should be part of every teacher's training. All teachers can and are facing the demand to incorporate technology in their teaching (Al-Ammary 2012) especially in the current era which is characterised by advancements in ICT and online technological tools. Compared to Technology Education, Educational Technology is involved with a much narrower spectrum of technology. As a specialised field, one can qualify as an ICT or CIE. Here at Unisa we have the ICT personnel who are professional support staff to the academic staff in as far as using technology to facilitate their lectures. Our CIE colleagues teach teacher trainees to integrate technology in their teaching. Enrolment of these teacher trainees is not conditional to any specific teaching subject as all teachers should be trained in integrating technology in their teaching.

Another way to distinguish between Technology Education and Educational Technology is through the key words and phrases which pertain to each. The National Educational Technology Standards for Students related to Educational Technology include the following key words: use of technology; media; multimedia; hardware and software; information; telecommunications; web environments; communicate; process data; use technological resources for solving problems; locate, evaluate, and collect information; and other instructional technology terms (Dugger & Naik 2001:32). Technology Education, on the other hand, uses the key words design, creativity, critical thinking, solutions/needs/wants, investigation, making, evaluate and communication. A word of caution here: both the Technology Education literature and the Educational Technology literature use the words 'technological literacy'. Furthermore, some of the key words listed here could also apply in both Technology Education and Educational Technology, for example, design in Educational Technology could mean the design of a lesson that incorporates technology. The term 'design' is central in Technology Education, meaning a much more sophisticated way of designing solutions to technological problems. Table 3 maps out the differences between Technology Education and Educational Technology through their features and scope and standards respectively. One should, however, be cautious because, apart from a few standards of Educational Technology such as technology communication tools, they sound pretty much like the features of Technology Education.

Table 3: Features and scope of Technology Education versus Foundation Standards for Educational Technology

Unique features and scope of Technology Education (Department of Basic Education 2011:8–9)	**Technology foundation standards (ISTE 2000:14–15)**
• To solve problems in creative ways • To use authentic contexts rooted in real situations outside the classroom • To combine thinking and doing in a way that links abstract concepts to concrete understanding • To evaluate existing products and processes; and to evaluate their own products • To use and engage with knowledge in a purposeful way • To deal with inclusivity, human rights, and social and environmental issues in their tasks • To use a variety of life skills in authentic contexts (such as decision making, critical and creative thinking, cooperation, problem solving and needs identification) • To create positive attitudes, perceptions and aspirations towards technology-based careers • To work collaboratively with others • Through practical projects using a variety of technological skills (investigating, designing, making, evaluating and communicating) that suit different learning styles.	Basic concepts and operations • Students demonstrate a sound understanding of the nature and operation of technology systems. • Students are proficient in the use of technology. Social, ethical, and human issues • Students understand the ethical, cultural and societal issues related to technology. • Students practice responsible use of technology systems, information and software. • Students develop positive attitudes towards technology that support lifelong learning, collaboration, personal pursuits, and productivity. Technology productivity tools • Students use technology tools to enhance learning, increase productivity and improve creativity. • Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications and produce other creative works. Technology communications tools • Students use telecommunications to collaborate, publish, and interact with peers, experts and other audiences. • Students use a variety of media and

Unique features and scope of Technology Education (Department of Basic Education 2011:8–9)	Technology foundation standards (ISTE 2000:14–15)
	formats to communicate information and ideas effectively to multiple audiences. Technology research tools • Students use technology to locate, evaluate and collect information from a variety of sources. • Students use technology tools to process data and report results. • Students evaluate and select new information resources and technological innovations based on their appropriateness for specific tasks. Technology problem-solving and decision-making tools • Students use technology resources for solving problems and making informed decisions. • Students employ technology in the development of strategies for solving problems in the real world.

Some associations' or conferences' names can also be misconstrued as meaning Technology Education. A case in point is the International Society for Technology in Education (ISTE). Note "Technology *in* Education", not "*of* Technology Education" – it is an association about Educational Technology. This is unlike straight forward names for association such as South African International Conference in Educational Technology (SAICET), International Conference on Science, Mathematics and Technology Education (ISTE), Southern African Association of Research in Science, Mathematics and Technology Education (SAARMSTE) and International Technology Education Association (ITEA), now International Technology Education and Engineering Association (ITEEA). Aligned to this is stakeholders' efforts to promote Science and Technology Education, including educational stakeholders through the Science Week campaigns, for instance. In most cases only Science Education gets emphasised in such efforts – as it can be noticed in this cited campaign's name, which sends a wrong impression that technology is science. If not, the technology component is dedicated only to technology integration in teaching or computer aided technology (CAT). Associations' names and subject promotional campaigns will however remain; care should be taken as to which ones are related to Technology Education and the extent of efforts to define, promote and represent Technology Education well.

But Petrina (2003:64) launches a challenge, that Technology Education equals to Educational Technology. I want to partly agree with him. He demonstrates this indifference in his article titled *The Educational Technology is Technology Education Manifesto.* In the article, Petrina relates the evolution of both Educational Technology and Technology Education having resulted from the 1920th Industrial Education and Audiovisual Education as subjects. Industrial Education predominantly targeted boys, i.e. to provide especially working class children with the knowledge, skills and values, which would make them survive the effects of industrialisation (Petrina 2003:65). Audiovisual Education, on the other hand, was a teacher education subject which targeted especially women, to equip them with the knowledge, skills and values to integrated mass communication technology in their teaching, namely cinema and radio

(Petrina 2003:65). Industrial Education mostly happened in the workshops whereas Audiovisual Education happened in the university laboratories dedicated to instruction. According to Petrina, ITEA is in the business of promoting standards for technological literacy, just like ISTE which is promoting standards for technology literacy as it can be observed in table 3. He however confronts the idea that both ITEA and ISTE are caught up in theoretical differences, when the masses' observation of indifference is informed by practice. Petrina seems not to see any problem in the National Teachers Association and American Federation of Teachers conflating Technology Education with Educational Technology. The main thrust of the "Technology Education is Educational Technology" argument is that the practices of these two are information communication-based so much that "when it comes down to IT, TE and ET teachers are technology teachers". Petrina (2003:70). To call Educational Technology teachers Technology Education teachers has the potential to add to the confusion about the meaning of Technology Education. Educational Technology teachers teach about the integration of technology in teaching, not about teaching Technology, which far much broader. I would rather we stay with different names of the teachers as guided by the names of these disciplines.

My take goes like the approach that I adopted in relating the comparisons between Technology Education and Science Education. As much as we should not concentrate on the differences only, but acknowledge the complementary nature of Technology Education and Science Education for the meaningful learning of Technology, so we should with Technology Education and Educational Technology. Much of what happens in the Technology Education workshop is driven by Educational Technology. Petrina (2003:70) agrees: "granted, ET may be a subset of TE". I concede that it does not come as a surprise, that much of the design activities in Technology Education do not happen hand-written anymore because of the influence of Educational Technology especially in today's era when digital technologies make inroads into the classroom. In fact, computer-aided drawing has been intentionally integrated in the Technology Education workshops. However, Educational Technology is a need for every teacher to help facilitate learning much effectively and interestingly. The difference with the set-up in schools is that many subjects are not lab-characterised like the other few such as Technology Education.

2.3 Technology Education is not Technical Vocational Education and Training

It is important to differentiate between Technology Education and Technical Vocational Education and Training (TVET) because Technology Education started in the form of vocational training and the influence of the industrial sector on it has been and still is too strong (Sanders 2003; Stevenson 2003; Ginestié 2005; Gumbo & Makgato 2008) and thus there is a very thin line between it and Engineering Education as well. Research enjoys comparing Technology Education with other fields, but its relationship to Vocational Education is under-researched (Sanders 2003).

Vocational Education means a planned series of learning experiences, the specific objective of which is to prepare individuals for gainful employment as semi-skilled workers or sub-professionals in recognised occupations, and in new and emerging occupations (Washington State Legislature 2011:21). Over time various terms have been used to describe the elements of the field of Vocational Education and Training, such as Apprenticeship Training, Vocational Education, Industrial Arts, Technical Education, Technical/Vocational Education, Occupational Education, TVET, and Career and Technical Education (Maclean & Lai 2011).

TVET is a labour-market relevant programme which includes work-based components such as apprenticeships (United Nations Educational, Scientific and Cultural Organization (UNESCO) 2011:11)). TVET refers to the "aspects of educational process involving, in addition to general education, the study of technologies and related sciences; as well as the acquisition of practical skills, attitudes, understanding, knowledge relating to occupations in various sectors of economic and social life" (UNESCO 2011:4). TVET is also understood as (UNESCO 2011:4):

- an integral part of general education;
- a means of preparing for occupational fields and for effective participation in the world of work;
- an aspect of lifelong learning and a preparation for responsible citizenship;
- an instrument for promoting environmentally sound sustainable development;
- a method of facilitating poverty alleviation.

In Europe, the term *Vocational Education and Training* is preferred, while *Career and Technical Education* is used in the United States.

TVET, also known in South Africa as Further Education and Training (FET), is offered by technical colleges. The Minister of Higher Education and Training has been stressing the need to promote and revamp TVET as a promising service to fast-track skills development in the country and as an alternative career path to university education. TVET systems are built to address these needs and to further promote personal, social, civic and economic development in the country (UNESCO 2015:6). This has resulted in the government producing a gazette on TVET (South Africa 2015), and institutions of higher learning are currently responding to the call by developing programmes in the TVET field.

Sanders (2003:182) argues that those who deny the existence of a relationship between Technology Education and Vocational Education are in denial considering the fact that the fundamental purpose for technological literacy is to contribute to the economy and workforce.

Thus far in this part of the lecture we have seen that Technology Education is not Science Education, Educational Technology or even TVET. Care should thus be taken not to define Technology Education in a manner that confuses it with these fields. The complimentary relationships especially between Technology Education and Science should however be acknowledged.

3. Technology Education

3.1 Definition

Let us consider a few definitions of Technology Education. Technology Education:

- encompasses but is not limited to, design, making, problem solving, technological systems, resources and materials, criteria and constraints, processes, controls, optimisation and trade-offs, invention and other topics that concern human innovation (Dugger & Naik 2001:31).
- refers to educating children to employ the hardware and software of technology. It includes educating theory and practice of a range of material processes for metal, wood, plastic materials and, more recently, textile, leather and food

materials. All these have a component of learning theory but the greater and more important is that of gaining practical experience (Kumar 2002:125).

- is about a study of technology which provides an opportunity for students to learn about the technological processes and knowledge needed to solve problems and to extend human capabilities (ITEA 2000:242)

From these definitions it can be noticed that Technology Education is a subject that provides learners with opportunities to learn the knowledge, skills and processes that pertain to technology and how they can apply these using different materials and techniques to effectively manipulate the environment while taking into account issues of sustainable development. Technology Education is a very important subject in the education of every learner because every country's development rests on it (Pudi 2007), and there is a dire need to prepare learners for the new industrial demands (Gumbo 2010).

Different names are used to refer to the subject of Technology Education, for example, in England it is called Design and Technology, in Ireland it is called Technology and Design (Ginestié 2005), whereas in South Africa it is called Technology (Department of Basic Education 2011). The use of the term 'Technology' is unfortunate because it can be mistaken for computers or ICT (Volk & Dugger 2005:60). It could have been termed Technology Education because in that sense it is distinguishable from other subjects, as I have explained in this lecture thus far.

The introduction of Technology Education can be briefly traced in terms of its developments and approaches.

3.2 Developments and approaches

The term Technology Education was introduced in the United States as an identified subject of study in the 1980s and it replaced industrial arts education (Litowitz & Warner 2008:251). Its introduction mushroomed in other contexts as well, making it a subject in its own right (Jones, Buntting & De Vries 2011:05). Some of these contexts include England, France, Finland, United States of America, Canada, Australia, New Zealand, India, Mainland China, South Africa, Botswana, Swaziland and Malawi. Different teaching approaches to Technology Education were suggested which guided each country's own approach. They include the following (Black, Raizen, Sellwood, Todd & Vickers in Gumbo & Makgato 2008:48–54):

Craft approach. This approach is characterised by knowledge and skills relating to materials that enable them to be transformed into fabricated objects; cultural and personal value; traditional design; learning activities that involve making things based on prescribed designs; classrooms that are equipped with machines and tools from the wood working, metal working, electrical, catering and textile trades. The emphasis tends to be on psychomotor skills and little design.

Occupational/vocational approach. This is characterised by hands-on transformation of materials into products; current industrial practice skills; classrooms that are equipped with machinery from industry.

High-tech approach. This is guided by a modern technological approach to industry; a desire to shape the skills base of a future workforce.

Applied science approach. This is defined by the scientific approach; use of science to explore new applications of Technology; study of science and technology in close association with each other.

Technology concepts approach. At the core of this approach lies learning processes that result in technological developments; theoretical understanding rather than practical action; a systems concept.

Design approach. This is characterised by a practical capability approach; active learner involvement in tackling realistic problems; design-make-evaluate activities. Its emphasis is on the learner's own decisions about what kind of product is needed and how the product should look, how it will work and how it should be made.

Science-technology-society (STS) approach. This is characterised by curricula organised around societal issues; connections between classrooms and the outside world; study of technological innovation as a driving force for social change; problem-solving.

Integrated subject approach. This approach integrates several subjects into a framework that provides understanding of Technology and its interrelatedness with other disciplines, for example Science, Mathematics and Technology.

South Africa has adopted a design approach, called a design process, which involves IDMEC – investigate, design, make, evaluate and communicate. Elements of other approaches are also integrated into this main adopted approach. The integrated approach is evident in the Intermediate Phase because Technology is taught as an integrated subject with the Natural Sciences, called Natural Sciences and Technology. Elements of the STS approach are also evident in the human rights, inclusivity and indigenous knowledge systems (IKS) which form the principles undergirding the curriculum. The craft approach, although not having a strong influence at the curriculum implementation level, is implied via the IKS principle and the fact that indigenous technology is specifically mentioned in the curriculum.

The design process is depicted according to Technomoodle (2010:1) in figure 2 and subsequently explained according to Mapotse (2001:60), Garratt (2004:9), Gumbo and Makgato (2008:25).

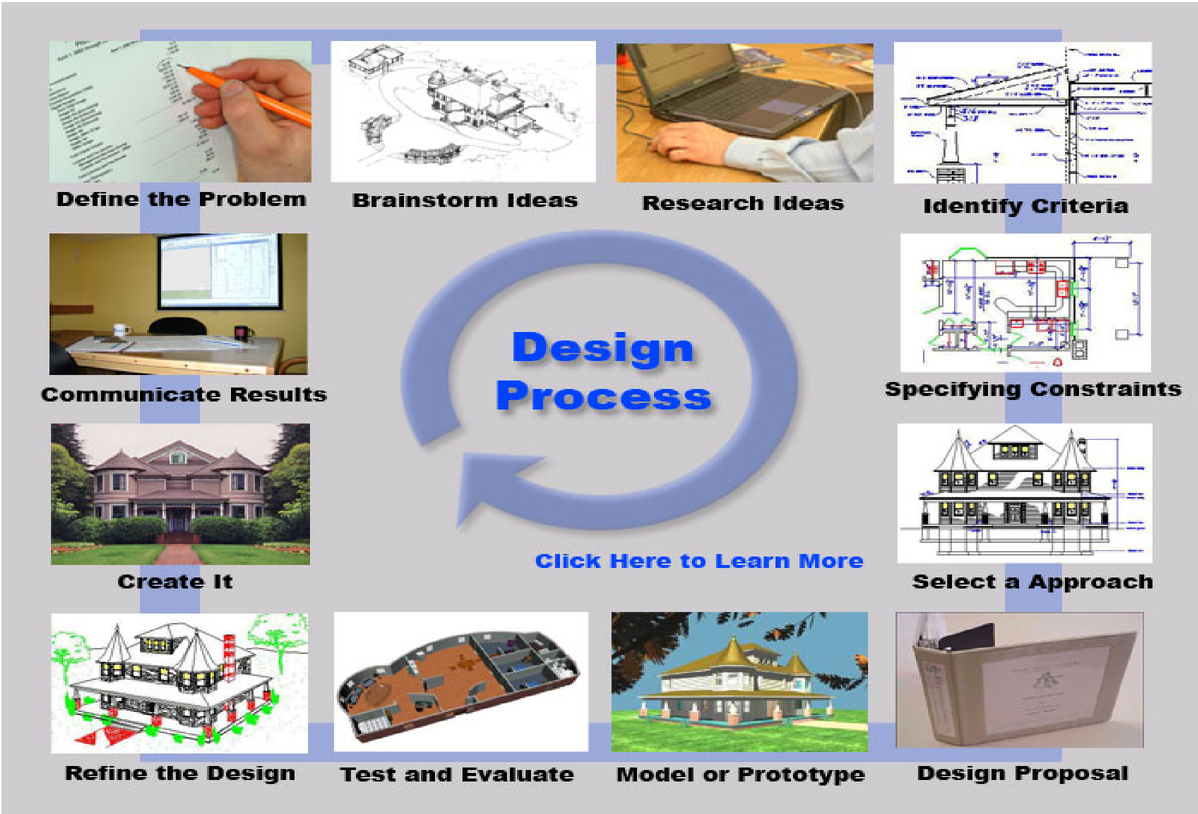


Figure 2: The design Process

Defining the problem: Define the problem clearly and fully. Ask yourself, what is the problem that I am trying to solve? This then forms the brief.

Brainstorming the ideas: Propose possible solutions individually or in small groups. At this point, all possible solutions should be considered, no matter how extreme they may seem.

Researching the idea: Research the problem. Start by searching for existing solutions to similar problems, and analyse both the good and the bad solutions.

Identifying the criteria: Criteria are what the product or system must do, for example a boat hull must carry a 2 kg mass 800 cm without tipping or sinking.

Specifying the constraints: Constraints are the limits imposed on the design solution. This is often related to resources, size, materials, and the like, for example, the boat hull must be more than 50 cm wide and less than 100 cm long.

Selecting an approach: Decide on a design that meets the specifications, fits the criteria and constraints, and has few negative effects. Select a preferred solution.

Designing a proposal: Lay out the design using technical sketches, then create detailed orthographic multi-view drawings. Prepare the working drawings and plan ahead.

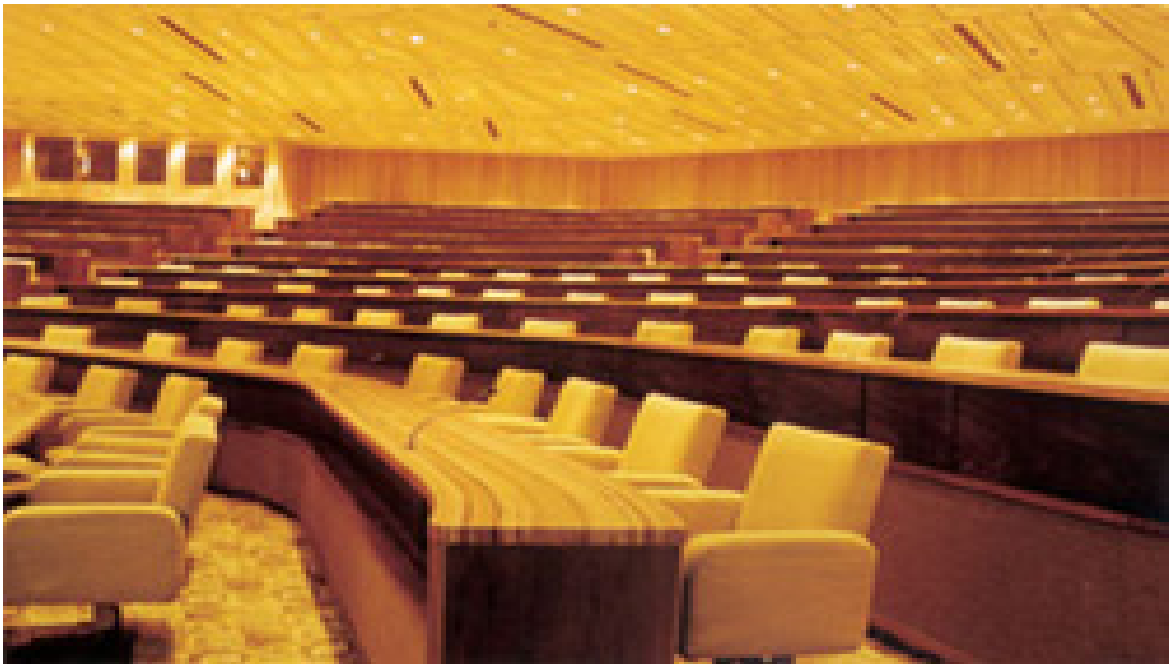
Creating a model or prototype: A model is a scaled version of the final product with all parts in correct proportion to the object. A prototype is a full-scale fully operational version of the solution.

Testing and evaluating the design: See how well the design satisfies the original criteria and constraints. Examine the solution's strengths and weaknesses. Change any variables that affect the performance of your design.

Creating the artefact: Create the final design with all the changes, improvements and modifications, that is, construct the prototype.

Communicating the results: Share your solutions and how you obtained them with others. Write a report.

How many of us would think of the design of the Senate Hall in which we are now as a product of design? We are sitting on what was once a hill covered with natural forest surrounded by fauna and flora, as well as rocks. In order to meet humanity's intellectual needs, a designer came up with an idea that would change this environment; an idea that can be analysed according to the design process described above. For example, the constraints were that it had to seat 230 people and offer everything required for a successful conference. The wooden panelling and the warm golden shades of the décor make this an elegant venue aesthetically. The hall is equipped for conferences with microphones and translation booths. For comfort and convenience it includes a registration desk at the entrance, conference microphones, microphones on the chairperson's desk, a podium with a fitted microphone, a video/data projector and 4 x 3 metre screen with many other e-system tools.



Unisa's Senate Hall
http://www.unisa.ac.za/Default.asp?Cmd=ViewContent&ContentID=14331

In Technology Education therefore, learners are either given a problem scenario or are asked to come up with one, depending on their level. They are then expected to approach their learning activity as a project that involves the design process explained above.

The design process follows a number of models which guide the teaching of Technology. These include the design loop (figure 3), linear (figure 4), circular (figure 5) and interactive models. Ter-Morshuizen, Thatcher and Thomson (1997:11–12) contributed the first three models, while ITEEA (2011) contributed the fourth. It should, however, be noted that the linear model has fallen into disfavour for its limitations in promoting critical and creative thinking in learners.

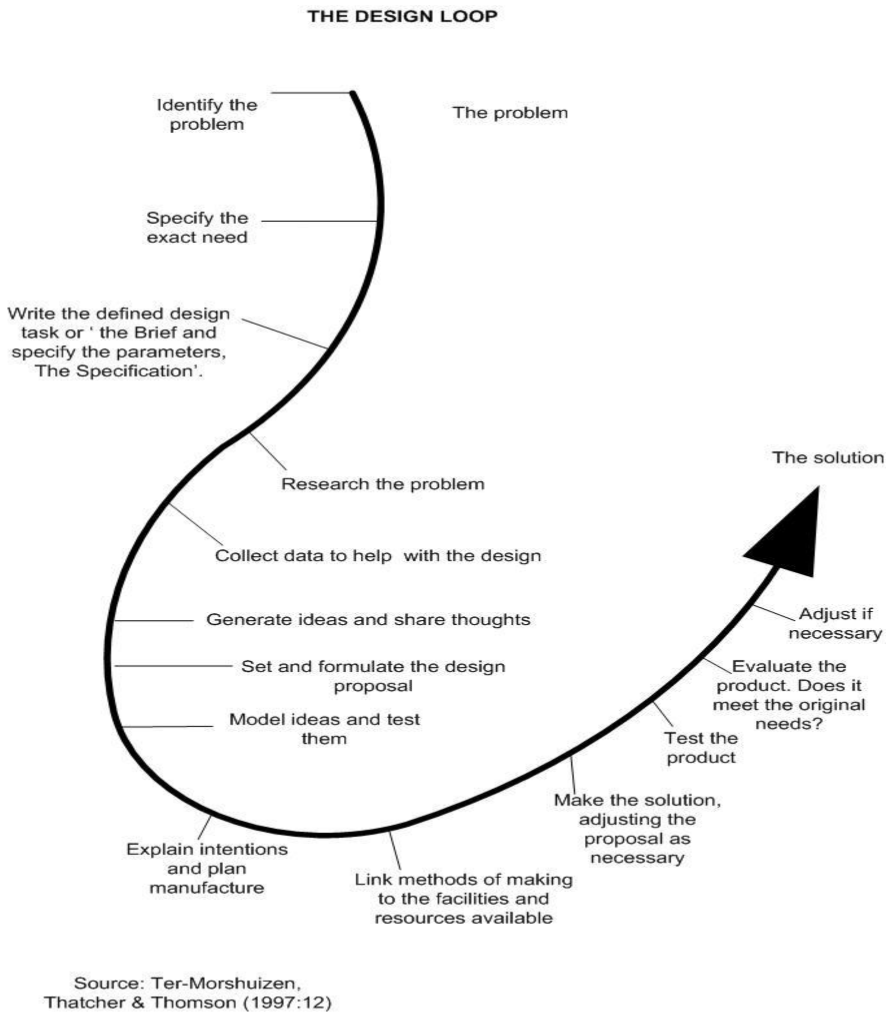


Figure 3: Design loop model

The design loop model (figure 3) seeks to promote creative and critical thinking, effective group dynamics, management skills, research and information handling, communication and socio-environmental awareness in learners (Gauteng Department of Education, 2010). Guided by this model, the design process follows consecutive and progressive steps until the process has been completed.

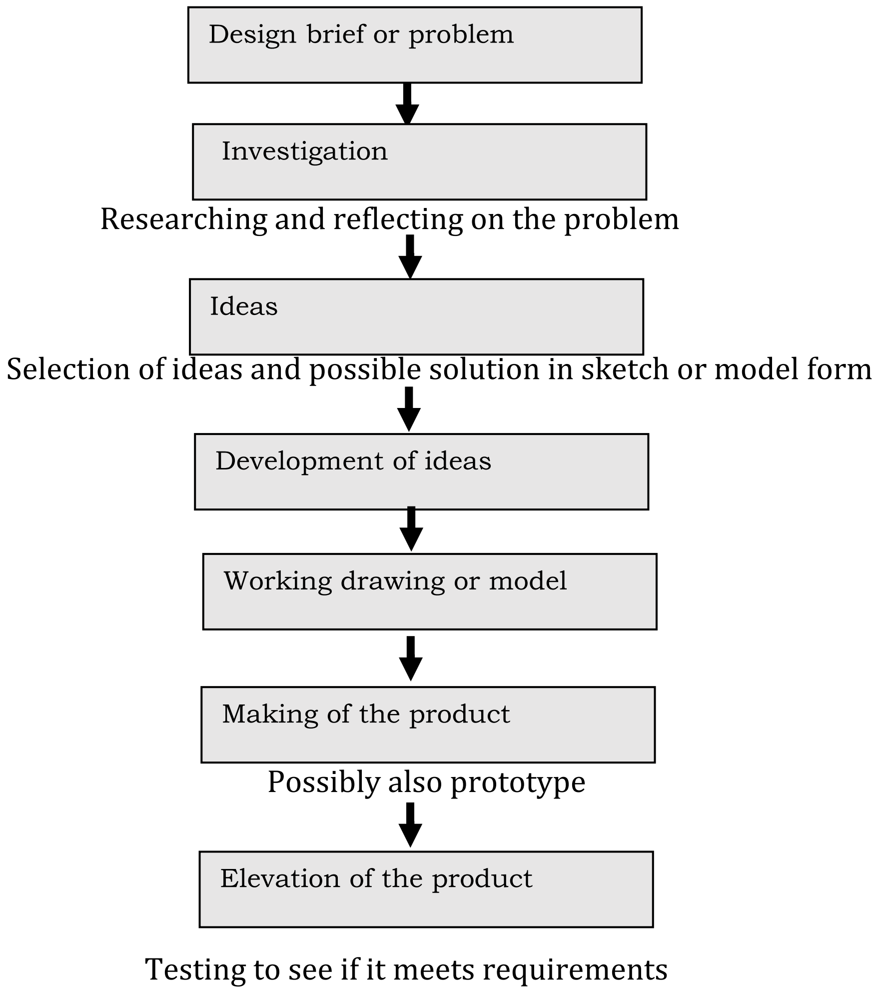
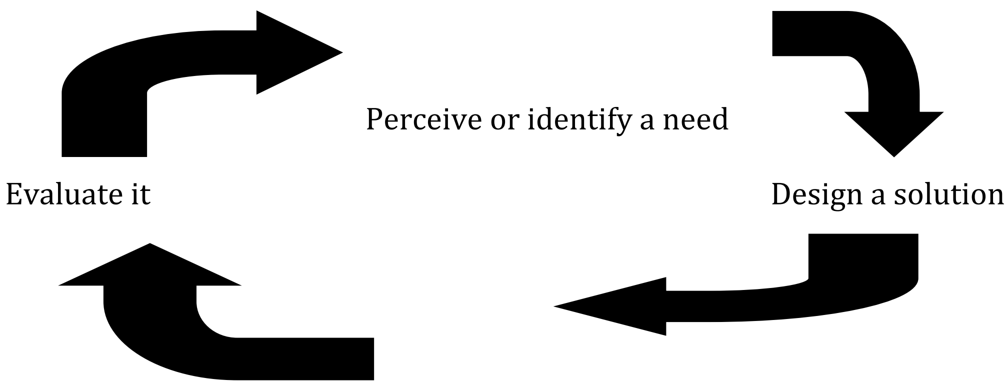


Figure 4: The linear model

The linear model of design process integrates theory and practice. This model is based on a sequential process which begins with the perception of a need, continues with the formulation of a specification, the generation of ideas and a final solution, and ends with an evaluation of the solution.



Make it

Figure 5: Circular model

The circular model implies that the design process follows consecutive, circular and progressive steps until the process has been completed.

The interactive model makes learners demonstrate both reflective and active capabilities as they interact with one another. There is constant interplay between active steps and a range of thinking activities.

The linear model is not as popular as the others models owing to its limitation in involving the design process uncritically and the lack of evaluation applied to other steps rather than being fixed on one only.

3.3 Technology (Education) in South Africa

As indicated in section 3.1, Technology Education in South Africa is called Technology. It is 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" (DBE 2011:8). Its specific aims are stated thus:

"Technology as a subject contributes towards learners' technological literacy by giving them opportunities to:

- develop and apply specific design skills to solve technological problems;
- Understand the concepts and knowledge used in Technology education and use them responsibly and purposefully.
- Appreciate the interaction between people's values and attitudes, technology, society and the environment".

The topics and core content areas covered are Design Process Skills, Structures, Processing of Materials, Mechanical Systems and Control, Electrical Systems and Control, and Technology, Society and Environment. In the Intermediate Phase, that is, Grades 4 to 6, Technology is integrated with Natural Science, and the specific aims and content at that level differ from those given above. The four specific content areas for the Senior Phase, namely, Grades 7 to 9, include Structures, Processing, Mechanical Systems and Control, and Electrical Systems and Control. The content for the Further Education and Training, namely, Grades 10 to 12, includes Civil Technology, Mechanical Technology, Electrical Technology and Engineering Graphics and Design. The design process is the backbone of the teaching method for Technology and is thus aimed at developing learners' design skills, as outlined in 3.2.

The South African curriculum was framed from the Constitution and thus recognises principles such as IKS, inclusivity and human rights. The content area, Technology, Society and Environment, includes the impact of technology, the bias of technology and indigenous technology. The inclusion of indigenous technology can be viewed as a move to ensure the infusion of IKS. Specifically, the quote from the Curriculum and Assessment Policy Statement goes as follows (Department of Basic Education 2011:10):

> Wherever possible, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights.

Ironically, this statement compromises the indigenous perspective for a few reasons. The phrase "where possible" does not convey a message of commitment about ensuring the integration of indigenous technology. Given the long history of the marginalisation of indigenous knowledge in South Africa, I feel that this phrase should have not been included because it allows room for indigenous technology not to be integrated, thus making indigenous technology even more vulnerable to exclusion. The second salient point for me is in the phrases "made aware" and "become aware". This does not really mean integration but merely to make learners aware. Making learners aware and teaching them about indigenous technology are two different things – creating awareness does not obviously translate into knowledge acquisition. The third point is "have used". This is a very unfortunate way to try to integrate indigenous technology because it suggests it is only a past history. This part of the aim of Technology should have rather been stated as follows: *Learners should learn about different coexisting knowledge systems and how indigenous cultures use specific materials and processes to satisfy needs, as well as indigenous intellectual property rights.*

The integration of indigenous perspectives in the Technology curriculum and in teaching is a response to the principles of the curriculum through addressing the important aspect of sustainable development. The National Strategy for Sustainable Development (NSSD), approved by the South African Cabinet in 2011, opens with a vision statement for a sustainable society by the (NSSD), which states thus:

> South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration (NSSD 2011:ii).

The Brundtland Commission defines sustainable development as "the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Robert, Kates, Parris & Leiserowitz 2005:10).

This definition of sustainable development contains two important words:

- *Sustainability,* which is about nature (earth, biodiversity, ecosystems), supporting life (ecosystem services, resources, environment) and community (cultures, groups, places).
- *Development,* which is about developing people (child survival, life expectancy, education, equity, equal opportunity), the economy (wealth, productive sectors, consumption) and society (institutions, social capital, states, regions) (Robert et al 2005).

The main thrust of the NSSD document is that it links sustainable development to indigenous communities' development and sustainability. Consequently, Technology becomes crucial in the development of human capital in this regard. For this reason it is important to provide an indigenous technological perspective in the content and teaching of Technology. Such a perspective encapsulates the idea of indigenous knowledge as being unique and closely related to a particular culture or society and can thus be referred to as local/traditional knowledge, folk knowledge, people's knowledge, traditional wisdom or traditional science (Senabayake 2006). Because indigenous knowledge is mostly evident in practical activities such as agriculture, food preparation and conservation, health care and education (Senanayake 2006), it is fitting to refer to it as technology. Technology is therefore considered in this sense as social capital for the poor because it is their medium for sustainability and the "main asset to invest in the struggle for survival, to produce food, to provide for shelter and to achieve control of their lives (Senanayake 2006:87).

The indigenous perspective introduces the tangible (material) and non-tangible (non-material) forms of Technology into the game of understanding Technology Education, with culture being the root cause for these forms (Ogungbure 2011). Moalosi, Popovic, Kumar and Hudson (2005) and Obikeze (2011) refer to these expressions of technology as tangible or intangible devices, formulations and techniques that fulfil some need or provide some service for humankind in a given environment. Three categories of these technologies include:

- *material (physical) technology*: bows and arrows, ploughs, looms, laboratories, machines, electronic devices, knives, fishing nets, explosives, etc
- *social technology*: methodologies, techniques, organisational and management skills, bookkeeping and accounting procedures, negotiating and counselling techniques and social institutions like patriarchy and women's league, songs, jokes, ideas, skills, and suchlike, and
- *communication technology*: language, signs and symbols, drumming, and the internet, and so on.

These cultural products are in turn organised according to goods and services and for that matter can be further subdivided into:

- *material goods*: soap, food items such as maize, houses, ornaments, aeroplanes, and television sets, and so on
- *social goods/services*: values, norms, customs, motherhood, priesthood and friendship, social services like concerts and plays, football games, health and healing systems and belief systems, and so on and
- *intellectual goods*: ideas, abstract concepts, names, terminologies, cognitive knowledge and idioms, and suchlike.

In the light of this cultural view of technology, Obikeze (2011) declares that technology is any human-made or culture-generated devices, formulations or organisations that may be used for the purpose of producing or creating needed goods and services. In a more elaborative way, technology refers to the knowledge, technical skills and resources available in the community and the environment that such a community occupies and which it uses to meet its needs. The concerned community adapts the natural environment for desirable human living and sustainability. Technologically, then, culture is characterised as the totality of the way of life evolved by a people in their attempt to meet the challenges of living in their environment; natural instinct to question the unknown to find a rational explanation for the way things are in the universe – seek understanding of the environment, harnessing the resources therein, making use of earth's possessions that have been the principal force in the development of humankind and society (Ogungbure 2011:88).

We can notice in this part of the lecture, that South Africa has chosen the approach to Technology Education which is aligned to the design concept which it has anchored the teaching of Technology on, as well as to promote the integration of IKS. The definition should however embrace the IKS perspective.

4. Technology

4.1 Definition

Indications in the literature are that it is not easy to define the term technology (Heidegger 1977; Dugger 2008; Le-Hua, 2009; Misa 2009; Mapotse 2012). The word Technology is probably one of the most overused and least understood terms (Mapotse 2012:15). The obvious reasons behind this difficulty are the high speed at which technology changes, and the different versions of technology which are context-based, so much so that the understanding of technology applicable in one context is different from that in another context, for example the fishery technologies on the Western Cape coast compared to the agricultural technologies of Limpopo Province. Table 3 presents the different focal areas used to define Technology.

Table 4: Foci of definition of Technology

Technology:	modify natural environment for human purposes (International Technology Education Association, 2000:9; 2007:2) understand natural world and produce solutions to problems (Miles 1995) improve surroundings (Kalanda 2005)	associated with high-tech, or high-technology, industries (Li-Hua 2009:18)	information, about production processes and product design (Contractor & Sagafi-Nejad 1981; Dean & LeMaster 1995:19 information, rights and services (Contractor & Sagafi-Nejad 1981) information about processing to achieve outcome (Maskus 2004:9) technical and commercial information (United Nations Conference on Trade and Development, in Li-Hua	includes bought and sold goods (United Nations Conference on Trade and Development, in Li-Hua 2009:19)	technical means (Kalanda 2005)	knowledge and know-how (Vohra in Ankiewicz, De Swart & Stark 2000:22; Li-Hua 2009:19; DBE 2011)

			2009:19)			

Let me take a few examples from table 3 that define Technology in detail:

- "The word technology usually conjures up with different images and generally refers to what has been described as the high-tech, or high-technology, industries – limiting technology to high-tech industries such as computers, superconductivity, chips, genetic engineering, robotic, magnetic railways and so on" (Li-Hua 2009:18).
- Technology is the technical means people use to improve their surroundings (Kalanda 2005).
- Technology concerns technological knowledge, skills and technological processes, and it involves the understanding of the impact of technology on the individual and society. It is the subject which is designed to promote the capability of the learner to perform effectively in his/her technological environment and to stimulate him/her to contribute towards its improvement (Ankiewicz, De Swart & Stark 2000:40) (defined as a subject in the South African context).

The last column in table 4 is about the knowledge aspect of technology. Owing to the close relationship between knowledge and technology, some scholars refer to technology interchangeably with know-how (Li-Hua 2009:19). Knowledge is defined as "a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information" (Li-Hua 2009:20). Knowledge consists of truth, beliefs, perspectives, concepts, judgements, expectations, methodologies, and know-how; it exists in different forms such as tacit, explicit, symbolic, embodied, en-brained and en-cultured knowledge (Li-Hua 2009:20). Technological knowledge consists of explicit, conceptual, procedural and tacit knowledge although tacit knowledge is not so popular because it is hard to explain.

According to Li-Hua (2009:20–21), tacit knowledge could be expressed through the existence of a much softer technology which contains less physical resources. Furthermore, Li-Hua is of the view that tacit knowledge is transferred through intimate human interactions because it cannot be codified. It has a competitive edge as it is not easy for its competitors to replicate it (Li-Hua 2009:21). Tacit knowledge is an aspect of experiential knowledge, while tacit knowledge is an aspect of explicit knowledge – experiential knowledge is characterised by tacitness, physicality and subjectivity, while rational knowledge is explicit, metaphysical and objective. Tacit knowledge is created here and now in specific, practical contexts, while explicit knowledge is about past events or objects there and then (Li-Hua 2009:21). Li-Hua (2009:21) illustrates this claim by using the example of China. Through technology transfer China has obtained hardware such as machinery, equipment, operational manual, specification and drawing, but it has produced the soft side from its tacit knowledge, including management expertise and technical know-how and know-why.

4.2 Dimensions of the technological definition

In this section I look at the dimensions of the definitions of technology to further enhance our understanding of the same. These are the historical, cultural, instrumental and anthropological dimensions.

4.2.1 Historical dimension

Historians of technology have had such a tough time defining technology that they have avoided formulating one (Li-Hua 2009:8). Even a renowned historian of technology such as Thomas Hughes admitted: "Defining technology in its complexity is as difficult as grasping the essence of politics" (2004:2). Apart from the reasons given in section 3 about the difficulty of defining technology, Li-Hua (2009) advances reasons that relate to different professional fields. In that sense, Li-Hua (2009) declares that technology is the end product of one's research: to a scientist it is a tool or process that can be employed to build better products or solve technical problems; to an engineer, it is intellectual property to be protected and guarded; to an attorney, most importantly yet least understood, it is a company asset to a business executive.

Technology expresses the statuses of developing and developed countries. It is a strategic instrument for achieving economic targets and creating wealth in these two contexts (Li-Hua 2009:18). The mega western technological systems such as electricity, industrial production and transportation have enjoyed dominance in this regard (Li-Hua 2009). Another important consideration is to define technology from a user's perspective, a thing that has been neglected for a long time. A manager or a business executive might have a different perspective (as stated above) to, say, a worker or an individual consumer (Le-Hua 2009:8). This results in an above-below view of technology. According to Le-Hua (2009), the above view leaves the impression of large systems spreading across time and space – maps showing the increasing geographical spread of railways and highways or statistical tables showing the increasing pervasiveness of such electrical consumer goods as irons, refrigerators and televisions. The below view may give meanings these technologies have for subcultures and show a great deal of creativity, for example farmers invented new uses for Henry Ford's classic Model T automobile as a source of power when adapting it for use on the farm; the widely popular invention of email was at the start "unplanned, unanticipated, and most unsupported" (Abbate 1999:109) by the original designers of the Internet; Japanese teenagers created new uses for mobile pagers and cell phones, and created a new culture in doing so (Ito, Okabe & Matsuda 2005). Very often these activities were not originally in the mind of the system designers, but could later be taken on by merely complicating any tidy definition of technology.

Technology institutes were kick-started in America and Europe in the late 1800s to mid-1900s and were associated mainly with men (Li-Hua 2009:9). Recently, the term *technoscience* is favoured by philosophers and historians of technology, motivated by advocates of the term maintaining that the practices, objects and theories of science and technology, even if they once were separate professional communities, have blurred to a point at which they share many important features (Li-Hua 2009:10). This term seems to confirm the synergy that exists between technology and science. However, it would not hold in the face of discourses that try to defend one or the other.

4.2.2 Cultural dimension

Technology can also be given expression through culture, that is, in technology we see a representation of culture and there can be a hybridisation of cultures through technological transfer, but it also can be used as a tool to oppress certain cultures. To illustrate technological hybridisation as an agent of cultural exchange/mix/oppression – "what we might today consider to be quintessentially Japanese came rather late to Japan" (Misa 2009:11). Technological hybridisation between Japan, China and Korea resulted in agricultural technology, techniques for working with bronze and iron, and for weaving, silk-making and paper-making. Two prototypically western technologies entered Japan. The first was gunpowder weapons in 1543 as a result of the Portuguese ship that was wrecked off the coast of the iron-rich and metalworking skilled Tanegashima Island on which the survivors landed. The Japanese copied the Portuguese gun and connected it to the mainland with trade. The second was the western style mechanical clock in 1551. The Japanese modified its design to suit local conditions. However, later on Japan converted to western time practices with the development of Japanese culture viewing the west as a panacea for the coming modernity.

In the 18th century, the political and cultural influence of Islamic Arabs extended through North Africa into present-day Spain, evidenced through the Islamic technology in eastern Spain in the form of Persian-style qanat irrigation techniques. A western computer might be designed in Silicon Valley, but software is increasingly written by programmers in China and India, with many components of personal computers manufactured in Taiwan, Hong Kong, China and other formerly Far Eastern countries. About 500 large containers (40 feet in length) arrive each month in the port of Lagos, Nigeria, packed with obsolete computers and other electronic equipment. Lagos has an active market in recycling these components.

Misa argues that the west's technological dominance has forced a paradigm in terms of which the world is conforming in the sense that there are numerous ways in which western and non-western technologies share significant characteristics that typify western technologies. These include:

> … the ability to extract mechanical energy from fossil fuels; the creation of integrated systems of mass production linking raw materials, production and consumers; the spread of uniform technical standards; the ability to manufacture tools and products to increasing mechanical precision; the mobilization of large capital and financing; the deployment of scientific knowledge; and a commitment to continuous renewal through research and development (Misa 2009:14).

According to Misa, these technological capabilities have made it possible for humans to alter the world's climate or even destroy its population. Not only have they done this, but they have also changed the cultural and social behaviour.

4.2.3 Instrumental and anthropological dimension

This dimension is based on the instrumentalisation theory (Feenberg 2009). According to this theory, instrumentality is taken to be the fundamental characteristic of technology (Heidegger 1977:5). The manufacture and utilisation of equipment, tools, and machines, including the manufactured and used things, and the needs and ends that they serve, are all the contrivance known as technology, namely, instrumentum (Heidegger 1977:1–2). Technology is a means, a human activity, whereby something is effected and thus attained, that is, it is instrumental (Heidegger 1977:2). But a means has a cause. "Whatever has effect as its consequence and the end in keeping with which the kind of means to be used is determined, is called a cause" (Heidegger 1977:2). "Wherever instrumentality reigns, causality reigns" (Heidegger 1977:2). There are four causes (occasioning) (Heidegger 1977:2–3):

- *Causa materialis*: the material, the matter out of which, for example, a silver chalice is made;
- Causa formalis: the form, the shape into which the material enters;

- Causa finalis: the end, for example, the sacrificial rite in relation to which the chalice required is determined as to its form and matter; and
- Causa efficiens: which brings about the effect that the finished, actual chalice, in this instance, the silversmith.

These four causes are responsible for letting what is not yet present arrive into presencing (bringing-forth/poiēsis) (Heidegger 1977:4). Bringing-forth brings out of concealment forth into unconcealment/revealing. The possibility of all productive manufacturing lies in revealing (Heidegger 1977:5).

The term technology stems from the Greek word, *technikon*, which is that which means technē. We must observe two things with respect to the meaning of this word. One is that technē is the name not only for the activities and skills of the craftsman, but also for the arts of the mind and the fine arts. Technē belongs to bringing-forth/poiēsis; it is something poietic (Heidegger 1977:5). The other point we should observe with regard to technē is even more important. From the earliest times until Plato the word technē was linked with the word epistēmē. Both words are names for knowing in the widest sense and they mean to be entirely at home in something, to understand and be an expert in it (Heidegger 1977:5). To understand means delving more and more into the realm of the unconcealed, ever searching for presencing the unconcealed.

Whenever man opens his eyes and ears, unlocks his heart, and gives himself over to meditating and striving, shaping and working, entreating and thanking, he finds himself everywhere already brought into the unconcealed. The unconcealment of the unconcealed has already come to pass whenever it calls man forth into the modes of revealing allotted to him. When man, in his way, from within unconcealment reveals that which presences, he merely responds to the call of unconcealment even when he contradicts it at times. Thus when man, investigating, observing, ensnares nature as an area of his own conceiving, he has already been claimed by a way of revealing that challenges him to approach nature as an object of research, until even the object disappears into objectlessness of standing-reserve (Heidegger 1977:9).

Meanwhile, man, precisely as the one so threatened, exalts himself to the posture of the Lord of the earth (Heidegger 1977:13). In this way the impression comes to prevail that everything man encounters exists only insofar as it is his construct. This illusion gives rise to one final delusion: It seems as though man everywhere and always encounters only himself (Heidegger 1977:14) – tower of Babel in Genesis 11:1-9. As man only saw himself he 'abused' technology to want to build his own heaven; to respond to a problem situation of fear of language confusion. "There is no demonry of technology, but rather there is the mystery of its essence" (Heidegger 1977:14). The actual threat has already affected man in his essence. The rule of enframing threatens man with the possibility that it could be denied to him to enter into a more original revealing and hence to experience the call of a more primal truth. "But where danger is, grows the saving power also" (Heidegger 1977:14).

These dimensions do impact on how we define Technology. They represent societal and professional communities (historians, cultures, instrumentalists and anthropologists) which perceive of technology from their own lenses.

5. Closing thoughts

To define Technology Education is not a simple but a complex and comprehensive exercise. The fact that it is confused with other subjects as it has been shown in this lecture, and that technology evolves rapidly, adds to the complexity of this exercise. Going forward, I propose a Technology Education Definitional Framework (in figure 2) to help researchers in their exploration of the meaning of the subject. I suggest that the exercise of defining Technology Education is an ongoing project due to the evolution of technology itself. Thus, the use of a revolving wheel for the framework is intentional to support this suggestion. The framework encapsulates different aspects which have been covered in this lecture, which form the scope of the exploration of the meaning. The scope can be expanded by building into the framework other aspects. Each aspect is explained subsequently.

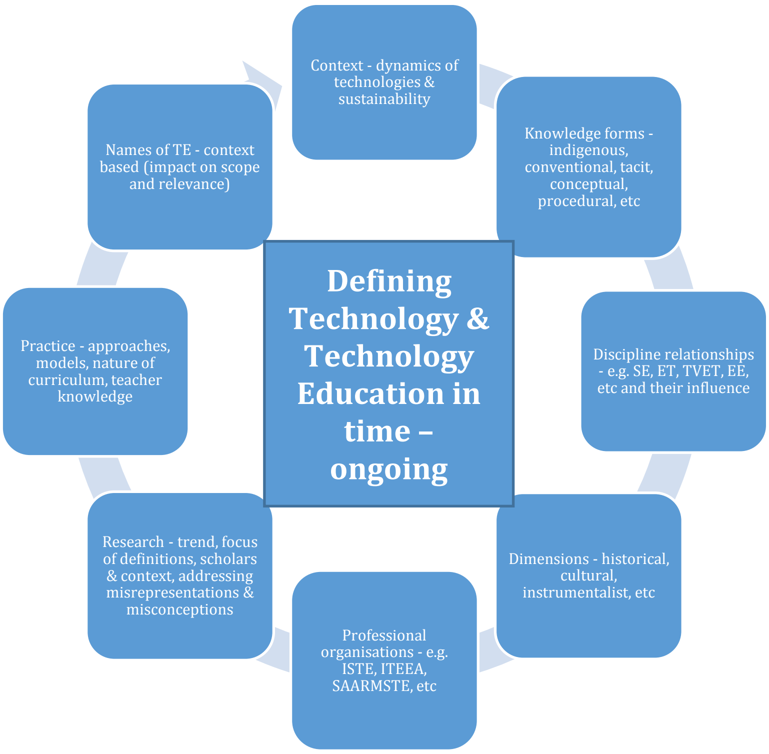


Figure 6: Technology Education Definitional Framework

Context

Technology is a contextual phenomenon which is guided by communities' activities and culture. In reference to the South African context I have defined Technology Education under 3.1. Learners' acquired technological literacy will position them to make a meaningful contribution towards technological developments and to be critical of their actions. A Technology definition which integrates sustainable development / indigenous technology is stated as: Technology is the manipulation and modification of the natural and/or man-made environment and resources using indigenous and/or conventional knowledge, skills and techniques in order to satisfy man's needs or wants and to solve problems. In the South African context where the promotion of IKS is crucial, attempts to define Technology Education should not marginalise the integration of thereof. Technology Education experts should thus help to guide the definition of Technology Education and how IKS can be integrated in the teaching of Technology to help build onto the meaning of the subject. I am currently engaging teachers in Mpumalanga Province as part of the Community Engagement project on the Strategic Intervention in Mathematics, Science and Technology Education, about the integration of IKS. I am also leading a project on writing a book for Technology Education teachers which integrates IKS.

Knowledge forms

Knowledge forms, which include tacit, explicit, symbolic, embodied, en-brained and en-cultured, conceptual and procedural knowledge, are aligned, though not limited, to context. The interaction of people across contexts, regions and nationalities causes knowledge exchange, hence, technological exchange or hybridisation. It is important that indigenous knowledge receives much attention given its subjugation by colonialism over decades. The teaching of Technology should as a matter of fact be expanded to include the IKS perspective. In an international comparative project between South Africa and New Zealand, my co-researcher and I found little to no attempt by teachers to integrate IKS in their practice. It was downplayed. A Technology Education definition that is devoid of the IKS perspective limits the understanding and teaching thereof. That is a disservice to indigenous learners who can contribute meaningfully in the learning activities, and non-indigenous learners who can be exposed to the indigenous forms and knowledge of technology. The dynamism and richness of knowledge that this form has should be not be downplayed in the teaching of Technology. This dynamism is flavoured with even other types of knowledge – experiential, presentational (story telling), propositional, practical, specialised and authoritative. These knowledge forms are sourced from organisational, practitioner, user, research and policy knowledges.

Discipline relationships

A good understanding of Technology Education is to know how it relates to other subjects, particularly Science Education, Educational Technology and TVET. Thus, effort should be made to teach about these relationship. Technology Education teachers should consider planning learning activities in which learners explore this relationship and let them discuss or debate about them. There is also a need for Technology Education teachers and Science Education teachers, for example, to collaborate rather than work in silos. The collaboration can be at the level of inter-resourcing the subjects, e.g. technological resources which can help with the teaching of Science, or at the level of content delivery, e.g. properties of materials while keeping in mind the purpose for learning about them in Technology Education compared to Science Education.

Dimensions

There are scholars who are informed from different backgrounds, who belong in the field of Technology Education. These include those who study the meaning of technology from a historical viewpoint, those who study the meaning of technology from a cultural or anthropological point of view, and those who study technology from the instrumentalist view. These views should be considered in the attempt to understand the meaning of technology.

Professional organisations

For purposes of academic activities such as conferences and affiliation, it is important to know how organisations differ especially in terms of naming and standards being promoted in their fields. This pertains to associations such as ISTE, SAICET and ITEEA. Of much consideration is the need to explore more the debates between ISTE and ITEEA about the so-called common factorness of IT to Technology Education and Educational Technology as a way to attempt to justify the 'Technology Education equals to Educational Technology' equation.

Research
Technology Education experts should still embark on research about its evolution in different contexts and revisit or build onto its definition in that sense. There is still a need to help define and promote the subject so that everyone should know what it really means. Experts can of course not avoid engaging in discourses on the international platform which will help direct the future understandings of Technology Education. The "Curriculum Issues in Technology Education" project that I am participating in is one such initiative that contributes to the understanding of Technology Education. This project engages international scholars in the field in round-table discourses and book writing. Perspectival approaches such as the one adopted in this lecture should be considered to guide attempts to define Technology Education.

Scholars who are not experts in Technology Education should reserve themselves from writing about Technology Education to avoid misinforming the society about what Technology Education is. This particularly refers to scholars who are experts of Educational Technology, TVET and Science Education, who might not notice the differences between Technology Education and these fields.

Practice
The current approaches and models of Technology Education may be affected by the development of research about the meaning of Technology Education. They therefore need to be revisited in keeping with new trends. There is still a need to train Technology Education teachers on the teaching and content knowledge in the subject. The fact that they volunteered to teach Technology at its inception in 1998, and that the training that most have received this far has only happened through in-service workshops, has left them still wanting about the knowledge in of the subject. If they still struggle with the knowledge of the subject, how much more the learners that they teach? The Department of Basic Education and Training should consider a specialised approach to the in-service training of Technology Education teachers. The training should not be approached just generally like in other subjects – it should have extended periods, much resourced especially for practical work, linked to universities for certification, etc.

The Strategic Intervention in Mathematics, Science and Technology Education is one of the ways in which an effort is made to help teachers with their teaching and content knowledge. The difference with this project is that the intervention is informed by the needs of teachers in the specific areas of the subject. The findings of the first phase of the project have helped to know the teachers' needs – curriculum knowledge, teaching the mini-Pats, electrical circuits, etc. My colleagues in my department and I are responsible for training teachers in the ACE (facing out and soon to be replaced by ADE) and PGCE. We are faced with challenges of teaching Technology at a distance, e.g. doing practical design activities. We constantly think of strategies to do better such as a plan to factor in practical work at the regional campuses. As a newer College of Education, we are also developing the new BEd and BEd Honours programmes in Technology Education.

Names of Technology Education
As part of the effort to understand the meaning of Technology Education, its context-based names should be known as well. It is not known by the same name like many subjects are. The naming of the subject has an impact on the understanding of the same as well as the type of approach and focus that can be followed.

We know best that which we ourselves make (Thomas Hobbes and Giambattista Vico in Dusek, 2009:137).

Thank you for your audience!

References

Abbate, J. 1999. *Inventing the Internet*. Cambridge: MIT Press.

Al-Ammary, J. 2012. Educational technology: A way to enhance student achievement at the University of Bahrain. *The Online Journal of New Horizons in Education* 3(3):54–65.

Ankiewicz, P.J., De Swart, A.E. & Stark, R. 2000. *Principles, methods and techniques of Technology Education.* Johannesburg: RAUKOG.

Chant, C. 1989. *Science, technology and everyday life 1870–1950*. London: Routledge Press.

Chisholm, L. 2003. The politics of curriculum review and revision in South Africa. *The Journal of Comparative and International Education* 35(1):79–100.

Contractor, F.J. & Sagafi-Nejad, T. 1981. International technology transfer: Major issues and policy response. *Journal of International Business Studies* 12(2):113–135.

Daugherty, M.K. & Wicklein, R.C. 2000. *Mathematics, Science and technology teachers' perceptions of technology education.* Available at: http://scholar.lib.vt.edu/ejournals/JTE/v4n2/pdf/daugherty.pdf. Accessed 24 July 2015.

Davies, D. 1997. The relationship between science and technology in the primary curriculum: Alternative perspectives. *The Journal of Design and Technology Education* 2(2):101–111.

Dean, C.C. & LeMaster, J. 1995. Barriers to international technology transfer. *Business Forum* 20(1):19–23.

Department of Education. 2000. *South African curriculum for the twenty-first century: Report of the Review Committee on Curriculum 2005*. Pretoria: Government Printers.

Department of Basic Education. 2011. *Curriculum and Assessment Policy Statement Grades 7-9: Technology*. Pretoria: Government Printers.

De Vries, M.J. 1996. Technology Education: Beyond the "Technology is applied science" paradigm. *Journal for Technology Education* 8(1): 7–15.

Dugger, W. 2008. The perspective of technology education. A paper presented at the Japanese International Symposium of Educational Cooperation for Industrial Technology Education. Chiryu, Japan.

Dugger, Jr, W.E. & Naik, N. 2001. Clarifying misconceptions between Technology Education and Educational Technology. *The Technology Teacher* September: 31-35.

Dusek, V. 2009. Introduction: Philosophy and technology. In J.K.B. Olsen, S.A. Pedersen & V.E. Hendricks (Eds.). *A companion of the philosophy of technology,* pp. 131-140. Malden: Wiley-Blackwell.

Feenberg, A. (2009). Critical theory of technology, in *A companion of the philosophy of technology,* edited by J.K.B. Olsen, S.A. Pedersen & V.E. Hendricks. Malden: Wiley-Blackwell, pp. 146–153.

Atlantic Provinces Education Foundation. 2001. Foundation for the Atlantic Canada Arts Education Curriculum. Halifax: Atlantic Provinces Education Foundation.

Fraser, D.M. 1996. Lessons for technology education from engineering education. Paper presented at the International Conference on Technology Education for Development in South Africa. Cape Town, South Africa.

Garson, P. 2000. A dose of realism for educationalists: Class struggle. *Mail and Guardian*, 4–10 February, p. 37.

Garratt, J. 2004. Design and Technology, 2nd edition. Cape Town: Cambridge University Press.

Gauteng Department of Education. 2010. *Gauteng Mathematics, Science and Technology Education improvement strategy 2009–2014*. Johannesburg: GDE.

Gil-pe'rez, D., Vilches, A., Fernana'ndez, I., Cachapuz, A., Praia, J., Valde, P. & Salinas, J. 2005. Technology as 'applied science': A serious misconception that reinforces distorted and impoverished views of science. *Science and Education* 14:309–320.

Ginestié, J. 2005. Teacher training, preparing young people for their future lives: An international study in technology education. Alix Marseille: IUFM.

Gumbo, M.T. 2003. Indigenous technologies: Implications for a Technology Education curriculum. Unpublished PhD thesis. Pretoria: Vista University.

Gumbo, M.T. 2010. A critical reflection on curriculum review of Technology Education in South Africa. Paper presented at the 4th Annual Teacher Education at a Distance Conference. Lanseria, South Africa.

Gumbo, M.T. 2013. A bumpy ride: Curriculum change and its impact on Technology Education in South Africa: Voices from the academy. Paper Presented at the 75th International Technology and Engineering Educators Association Conference. Columbus, USA.

Gumbo, M.T. & Makgato, M. 2008. Dealing with the relational aspects of Technology Education. Pretoria: Ithuthuko.

Gumbo, M. Makgato, M. & Müller, H. 2012. The impact of in-service Technology training programmes on Technology teachers. *Journal of Technology Studies* XXXVIII(1):23–33.

Heidegger, M. 1977. The question concerning technology and other essays. New York: Harper & Row.

Herschbach, D.R. 2001. *Technology as knowledge: Implications for instruction*. Available at: http://scholar.lib.vt.edu/ejournals/JTE/v7n1/pdf/herschbach.pdf Accessed 3 January 2016.

Hughes, T.P. 2004. *Human-built world: How to think about technology and culture*. Chicago, III: University of Chicago Press.

Indiana Technology Education Curriculum Standards. 2006. Technology Education content standards booklet. Indiana: Indiana Department of Education.

ISTE. 2000. *ISTE National Educational Technology Standards for Students*. Available at: http://www.hbgdiocese.org/wp-content/uploads/2012/04/NETS-for-Students.pdf Accessed 29 January 2016.

ITEA. 2000. Standards for technological literacy: Content for the study of technology. Available at: http://scimathmn.org/wp-content/uploads/2013/08/tech_standards.pdf Accessed 9 February 2016.

ITEA. 2000. Standards for technological literacy: Content for study of technology, 3rd edition. Virginia: Reston.

ITEA. 2007. Standards for technological literacy: Content for study of technology, 3rd edition. Virginia: Reston.

ITEEA. 2011. What is Technology teaching? Available at: http://www.iteaconnect.org/Resources/whatistechteaching.htm Accessed 15 January 2016.

Ito, M., Okabe, D. & Matsuda, M. (eds). 2005. Personal, portable, pedestrian: Mobile phones in Japanese life. Cambridge: MIT Press.

Jones, A., Buntting, C. & De Vries, M. 2011. The developing field of technology education: A review to look forward. *International Journal of Technology & Design Education* 23:191–212.

Kalanda, K. 2005. Factors influencing college students' attitudes toward Technology in Lesotho. Unpublished MEd dissertation. Pretoria: Unisa.

Kates, R.W., Parris, T.M. & Leiserowitz, A.A. 2005. What is sustainable development? Goals, indicators, values, and practice. *Environment: Science and Policy for Sustainable Development* 47(3):8–21.

Kim, J.S. 2000. Students' attitudes and perceptions toward technology. Retrospective theses and paper 13909. Available at: http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=14908&context=rtd Accessed 9 February 2016.

Kumar, K.L. 2002. Impact of new technology on teaching and learning in technology education. Paper presented at the Design and Technology Association International Research Conference. Available at: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/3167/1/Questioning%20the%20design%20and%20technology%20paradigm%20.pdf Accessed 9 February 2016.

Li-Hua, R. 2009. Definitions of technology, in A companion of the philosophy of technology, edited by J.K.B. Olsen, S.A. Pedersen & V.E. Hendricks. Malden: Wiley-Blackwell, pp. 18–22.

Litowitz, S.L. & Warner, S.A. 2008. Technology Education: A contemporary perspective. *The Phi Delta Kaplan* 89(7):519–521.

Maclean, R. & Lai, A. 2011. The future of technical and vocational education and training: Global challenges and possibilities. *International Journal of Training Research* 9(1–2):2–15.

Maluleka, K., Wilkinson, A. & Gumbo, M. 2006. The relevance of indigenous technology in Curriculum 2005/RNCS with special reference to the Technology Learning Area. *South African Journal of Education* 26(4):501–513.

Mapotse, T.A. 2001. Curriculum evaluation of Technology Education. Unpublished MEd dissertation. Pretoria: Technikon Northern Gauteng.

Mapotse, T.A. 2012. The teaching practice of Senior Phase Technology Education teachers in selected schools of Limpopo Province: An action research study. Unpublished DEd thesis. Pretoria: Unisa.

Mapotse, T.A. & Gumbo, M.T. 2013. Identifying Grade 8 and 9 Technology teachers' areas of need for intervention in Limpopo Province. *Journal of Social Sciences* 36(1):19–28.

Massachusetts Science and Technology/Engineering Curriculum Framework. 2006. *Purpose and nature of science and technology/engineering*. Malden: Massachusetts Department of Education.

McCormick, R. 1997. Conceptual and procedural knowledge. *International Journal of Technology and Design Education* 7:141–159.

McCormick, R., Murphy, P. & Hennessy, S. 1994. Problem-solving process in Technology Education. A pilot study. *International Journal of Technology and Design Education* 4(1):5–34.

Misa, T. J. 2009. History of technology, in A companion of the philosophy of technology, edited by J.K.B. Olsen, S.A. Pedersen & V.E. Hendricks. Malden: Wiley-Blackwell, pp. 7–17.

Maskus, K.E. 2004. Encouraging international technology transfer (Issue Paper 7). Available at: http://www.iprsonline.org/unctadictsd/docs/CS_Maskus.pdf Accessed 4 January 2016.

Miles, D. 1995. Constructive change: Managing international technology transfer. Geneva: International Labour Office.

Moalosi, R., Popovic, V., Kumar, K.L. & Hudson, A. 2005. Product analysis in relation to the socio-cultural perspective of Botswana. Paper presented at International Conference on Design Education. Ahmedabad, India.

Nokwali, M.P., Mammen, K.J. & Maphosa, C. 2015. How is Technology Education implemented in South African schools? Views from Technology Education learners. *International Journal of Educational Studies* 8(3):563–571.

NSSD. 2011. National Strategy for Sustainable Development and Action Plan (NSSD 1) 2011 – 2014. Pretoria: Department of Environmental Affairs.

Obikeze, D.S. 2011. Indigenous knowledge systems and the transformation of the academy in Africa: The CULPIP model. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.164.9357&rep=rep1&type=pdf Accessed 10 January 2016.

Ogunbure, A.A. 2011. The possibilities of technological development in Africa: An evaluation of the role of culture. *The Journal of Pan African Studies* 4(3):86–100.

Olsen, J.K.B., Pedersen, S.A. & Hendricks, V.E. (eds). (2009). A companion of the philosophy of technology. Malden: Wiley-Blackwell.

Petrina, S. 2003. The Educational Technology is Technology Education manifesto. *Journal of Technology Education* 15(1):64 – 74.

Pudi, TI. 2006. Technology education (Study Guide). Pretoria: Unisa Press.

Raat, J.H. & de Vries, M. 1985. What do 13-year old students think about technology? The concept of and attitude towards technology of 13-year old girls and boys. Eindhoven University of Technology, The Netherlands (ERIC Document Reproduction Service No. ED 262-998.

Richey, R.C. 2008. Reflections on the 2008 AECT definitions of the field. *TechTrends* 52(1):24–25.

Rooney, D. 1997. A contextualising, socio-technical definition of Technology: lessons from ancient Greece and Foucault. *Prometheus* 15(3):399–407.

Sanders, M. 2003. The perplexing relationship between Technology Education and Career & Technical Education in the US. Paper presented at the American-Australian Technology Education Forum. Gold Coast, Australia.

Senanayake, S.G.J.N. 2006. Indigenous knowledge as a key to sustainable development. *The Journal of Agricultural Sciences* 2(1):87–94.

Schuurman, E. 1995. Perspectives on technology and culture. Potchefstroom: Potchefstroom University Press.

Stevens, A. 2005. *Technology teacher education in South Africa*. Available at: http://www.iteaconnect.org/Conference/PATT/PATT15/Stevens.pdf Retrieved 26 January 2016.

Stevenson, J. 2003. Examining cognitive bases for differentiating Technology Education and Vocational Education. Paper presented at the American-Australian Technology Education Forum. Gold Coast, Australia.

South Africa. 2015. The National Norms and Standards for Funding Technical and Vocational Education and Training Colleges. *Government Gazette* No. 38796 of 15 May 2015. Pretoria: Government Printers.

Technomoodle. 2010. *The design process: Technology, engineering, design and virtual learning environment* – Online classroom. Available at http://www.technology education.org/technomoodle/thedesignprocess.html Retrieved 14 January 2016.

Ter-Morshuizen, K.J., Thatcher, C. & Thomson, R. 1997. *Primary Technology: Teacher resource book for Grades 1 to 7*. Cape Town: Shutter and Shooter.
UNESCO. 2011. *Introducing UNESCO's Technical Vocational Education and Training (TVET) definition and strategy*. Available at: http://www.uis.unesco.org/StatisticalCapacityBuilding/Workshop%20Documents/Education%20workshop%20dox/2011_Vina%20del%20Mar/English%20documents/10_TVET_UNESCO_OREALC_EN.pdf Accessed 29 January 2016.
UNESCO. 2011. Revision of the International Standard Classification of Education (ISCED). Paper presented at the UNESCO General Conference. 36th Session. Available at: http://www.emeraldinsight.com/doi/full/10.1108/S0195-6310%282013%290000030017 Accessed 9 February 2016.
UNESCO. 2015. World TVET Database South Africa. Bonn: UNESCO.
Volk, K.S. & Dugger, W.E. 2005. East meets West: What Americans and Hong Kong people think about technology. *Journal of Technology Education* 17(1):53–68.
Williams, A. 1996. What is technology? in Technology education for teachers edited by J. Williams & A. Williams. Melborne: MacMillan, pp. 1–26.
Yishak, D. & Gumbo, M. 2015. A stand-alone, blended or restructured indigenisation approach to curriculum? A critical perspective. *International Journal of African Renaissance Studies – Multi-, Inter- and Transdisciplinarity* 10(1):60–82.