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The *New Zealand Curriculum's* approach to technological literacy through the lens of the philosophy of technology

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Abstract

New Zealand's curriculum, in terms of its approach to technological literacy, attempts to deliver a sound, philosophy-based understanding of the nature of technology. The curriculum's main authors claim that it conforms well to Mitcham's (2014) categorization of different aspects of technology's nature. Nevertheless, taking advantage of the existing literature of the philosophy of technology, this paper will reveal that the intended curriculum, though an admirable approach, still has a number of points needing improvement, and there are also certain gaps to be bridged in the claimed conformity. This analysis primarily makes use of the method initiated by Nia and De Vries (2016a), based upon Mitcham's suggested framework and other philosophers' opinions as to the nature and various features of technology.

Key words The *New Zealand Curriculum*, Technology Curriculum Support, philosophy of technology, technological literacy, Mitcham's perspective, the nature of technology

Introduction

As a long-term policy document of technology education, *The New Zealand Curriculum* (NZC) (Ministry of Education of New Zealand, 2007) – in tandem with the complementary document: *Technology Curriculum Support* (TCS) (Ministry of Education of New Zealand, 2010) – aims to provide students with a deep, broad, and critical literacy in technology (Compton, 2007; Compton & France, 2006). These documents, accordingly, attempt to benefit from a focus on the philosophical basis of technology – an approach, it is claimed, that appropriately conforms to Mitcham's (1994) categorization and elaboration of the four main aspects of the nature of technology (Compton, 2007). That said, as an approach that takes advantage of the philosophy of technology to teach students about technology, New Zealand's curriculum can accordingly be subject to two evaluative questions from a philosophy-of-technology perspective: firstly, To what extent could such an approach foster a comprehensive understanding of the nature and various features of technology? and secondly, How well could that approach conform to a well-structured perspective – particularly, as claimed, to Mitcham's philosophical outlook on different aspects of technology?

Such questions are not particularly novel, nor is it even very new to suggest the philosophy of technology be employed to evaluate the approaches of technological literacy documents. Both concerns have been addressed in one way or another by scholars such as de Vries (2005), Jones, Buntting and de Vries (2013), and Nia and de Vries (2016a). They argue that the discipline of the philosophy of technology has to do essentially with explaining and elaborating different aspects of the nature of technology and, therefore, can provide a foundation of various viewpoints to enrich and fortify technological literacy studies. Nia and de Vries have developed a framework – based on Mitcham's perspective (discussed later) – for performing a robust analysis on the American case of *Standards for Technological Literacy* (ITEA, 2007), and have suggested that the method can also be applied to other cases such as that of New Zealand.

New Zealand's case, nevertheless, adopts a different style as a reference for teaching about technology than that of the USA: in contrast to the weighty body of the latter (entailing eight extensive chapters describing twenty standards) (see ITEA, 2007, p. 15), the former has attempted to offer a much less extensive document, in terms of both structure and content. The NZC comprises, as discussed later, only three main *strands* and eight *sub-strands* (known as 'components' in New Zealand's curriculum) supplemented with some prefatory explanation regarding how to engage with each of them in different levels of education (see Ministry of Education of New Zealand, 2010, pp. 9-10, 70-95).

Having said that, this paper begins with presenting a brief sketch of the approach of NZC (in tandem with TCS) to various aspects of technological literacy, and will then by analyse it according to Nia and de Vries's (2016a) proposed framework. The study will conclude with an overall discussion and related recommendations.

Prior to the main discussion of the study, it is worth mentioning that this analysis must be seen as a tribute to New Zealand's innovative approach. In contrast to most of the customary standards of other countries, NZC has made a serious attempt to incorporate the philosophy of technology in technology education plans – an attempt that, although not perfect, seems to have a promising potential to deliver more technologically literate students. This is why this case was selected for this study, in the hope of helping the curriculum to be improved even more in its subsequent versions.

The *New Zealand Curriculum*: Structure, approach, and content

NZC, as expounded through TCS, has strived to provide sound content for teaching about technology in the primary and junior secondary schools (Compton & Harwood, 2006; Ministry of Education of New Zealand, 2010). A structure described by Ministry of Education in New Zealand (2010) as "a dynamic and future focused framework for teaching and learning in technology [to give] the students challenging and exciting opportunities to build their skills and knowledge as they develop a range of outcomes through technological practice" (p. 4). It proposes a framework restructured around three strands: *Technological Practice*, *Nature of Technology*, and *Technological Knowledge.*

Each strand entails some sub-strands or components embracing the relevant topics and concepts required to be taught about technology (Ministry of Education of New Zealand, 2010). Table 1 is an overall summary of these.

Such an approach, including its specific structure and content, was asserted by its authors to benefit from a robust philosophical and theoretical base for technology education. Compton (2007), as the primary author, wrote:

> [The Nature of Technology] is focused on developing a philosophical understanding of technology as a discipline, including an understanding of how it is differentiated from other forms of human activity, and how technological outcomes differ from other artefacts. It rests upon a sociotechnological stance …, [and] learning within this strand focuses on developing philosophical understandings of two components - Characteristics of Technology and Characteristics of Technological Outcomes ... [Technological Knowledge] is focused on developing key concepts in technology that are generic to all technological endeavours, and … learning within this strand focuses on developing conceptual understandings of three components - Technological Modelling, Products and Systems… . [Finally, Technological Practice] provides students with opportunity to examine the technological practice of others to inform their own practice in an increasing sophisticated fashion. Student technological practice can result in the development of a range of outcomes, including concepts, plans, briefs, and technological models, as well as fully realised products or systems. Student learning within this strand focuses on developing capability within the three iterative components of Brief Development, Planning for Practice and Outcome Development and Evaluation. (pp. 10-12)

Table 1. The concepts and concerns related to the nature of technology in NZC (& TCS).

Strand	Sub-Strands (Components)
Technological Practice	Planning for practice Brief development Outcome development and evaluation
Technological Knowledge	Technological modeling Technological products Technological systems
Nature of Technology	Characteristics of technology Characteristics of technological outcomes

It was claimed that this approach would conform to Mitcham's perspective on various aspects of technology, in order to "support the development of a technological literacy that is broader, deeper and more critical than that achieved from the [previous version]" (Compton, 2007, p.13). This conformity was delineated as follows:

- Technology as Volition – addressed via Nature of Technology – specifically in terms of the Characteristics of Technology.
- Technology as Artefact – addressed via Nature of Technology – specifically in terms of the Characteristics of Technological Outcomes.
- Technology as Knowledge – addressed via Technological Knowledge – specifically in terms of Technological Modelling, Technological Products and Technological Systems.
- Technology as Activity – addressed via Technological Practice – specifically in terms of the Brief Development, Planning for Practice and Outcome Development and Evaluation. (Compton, 2007, p. 12)

Although this is an admirable approach that has barely been realized in other countries (even in the more extensive one of the USA), this case, too, can be subject to continuous improvement, as all curricula are reviewed and improved over time, with the recognition that ideas and contexts change. The thesis of this paper is that consideration of a number of philosophical issues could provide some additional rationale for changes to the NZ Curriculum, as suggested by Nia and de Vries (2016a).

Research method and analysis

The study's main purpose was to understand to what extent the *New Zealand Curriculum* can deliver a comprehensive understanding about technology, and how well such an approach conforms to Mitcham's philosophical outlook on different aspects of technology. The research was conducted by drawing on Nia and De Vries's (2016a) framework, which, as seen in Table 2, provides an analytical tool by taking advantage of philosophical reflections on technology, a discipline which "can afford a fertile ground of perspectives, content, and analyses to enrich and strengthen the tree of technological literacy studies." (Nia & De Vries, 2016a, p. 7).

That framework can be briefly explained in two parts:

i) The framework's main structure is principally rooted in Mitcham's perspective on the four aspects of the nature of technology, that is, technology as *object*, *knowledge*, *activity*, and *volition*. The background of such a categorization is well expounded by Mitcham (2001):

> In the most general sense, technology is 'the making and using of artifacts,' but we should look at four deeper aspects of this phenomenon. First, this making and using can be parsed into the objects that we make and use, such as machines and tools. This is 'technology as object.' Second, if we focus on the knowledge and skills involved in this making and using activity, that's 'technology as knowledge.' Third, there is the activity in which technical knowledge produces artefacts and the related action of using them: this constitutes 'technology as action or activity.' Fourth, there is another often overlooked dimension of 'technology as volition' —

> the will that brings knowledge to bear on the physical world to design products, processes, and systems. This technological will, through its manifestations, influences the shape of culture and prolongs itself at the same time. (n.p.)

Table 2. Concepts of technology from different aspects

Aspects of Technology			
Object	Knowledge	Activity	Volition
• Artefacts (as objects) • Systems • A (specific) Design	• Representation of knowledge & skills • Normativity • Interrelation of science & technology • 'Know-that' & 'know-how' • Creativity	• Designing • Evaluation • Modelling • Innovation • Invention • Needs, wants, & demands • Use plan	• Artefacts (as volition) • Value-sensitive design • Ethics, values, & moralities • Aesthetics • Social construction of technology • Sociotechnical systems • Different contexts of technology • Technology & metaphysics • Technology & politics • Technology & society • Technology & culture • Technology & economy • Technology & environment • Technology, future, & humanity

Source: Nia & de Vries, 2016a, p. 9.

ii) Regarding its content, nonetheless, Nia and de Vries (2006a) believe that there are many significant points in terms of the relevant concepts and concerns addressed by several other philosophers that could be embraced by the framework mentioned above. The points and concepts under the four main aspects shown in Table 2 are their findings in this regard, resulting from an extensive review of the existing literature of philosophy of technology, such as Dusek (2006), Kaplan (2004), Meijers (2009), Olsen, Pedersen, and Hendricks (2009), and Vermaas, Kroes, Van de Poel, Franssen, and Houkes (2011).

Such a framework, therefore, appeared to be a useful and practical tool for assessing the effectiveness of New Zealand's policy documents on technological literacy, just as it has been applied to the case of the USA. In order to accomplish an acceptable assessment, this study needed to make a concrete investigation into the documents of NZC and TCS. The investigation was conducted based upon a *qualitative data analysis*

(Bryman, 2012) and has benefited from an acceptable level of research quality by performing an iterative examination of texts and using an acceptable procedure of analysis.

Performing an iterative (three times or even more for some parts) examination of the texts – accompanied with necessary discussions of the results and comparing the findings of different stages of inspection – has led to an adequate level of *reliability* of the findings.

The study was underpinned by a procedure for observing, identifying, and analysing the intended cases, proposed by Mason (1996), and Bryman (2012) (Figure 1). The process of investigating the texts was initiated with the general question as to which aspects or properties of the nature of technology, as outlined by the philosophers of technology, can be recognized in the New Zealand policy documents. The study passed through the subsequent steps of selecting the relevant parts of NZC and TCS, i.e., examining the important sections and critical sentences or keywords that have to do in one way or another with the nature of technology (steps 1 to 3); gathering all the necessary data regarding the general question mentioned above; and, consequently, analysing and interpreting them with the aid of the proposed framework, portrayed as the circular loop of steps 4, 5, 5a, and 5b. The final stage (step 6) delineates the findings of the study. For instance, in order to see how different features and functions of 'modelling' are considered through NZC and TCS (step 1), all relevant sections and sentences, particularly the 'Technological Modelling' component, were examined to collect the necessary data (steps 2 & 3). Then data gathered were analysed and interpreted with the aid of the existing explanations of TCS (step 4), and an attempt was made to delineate them in a conceptual framework, through the lens of the philosophy of technology (step 5). This raised further, but more detailed, questions about various aspects of 'modelling' (5a) which led again to more focused data collection and interpretation steps modifying the conceptual framework (steps 5b, 4, & 5), a loop which finally led to some appropriate results and conclusions about the state of 'modelling' in NZC and TCS (step 6).

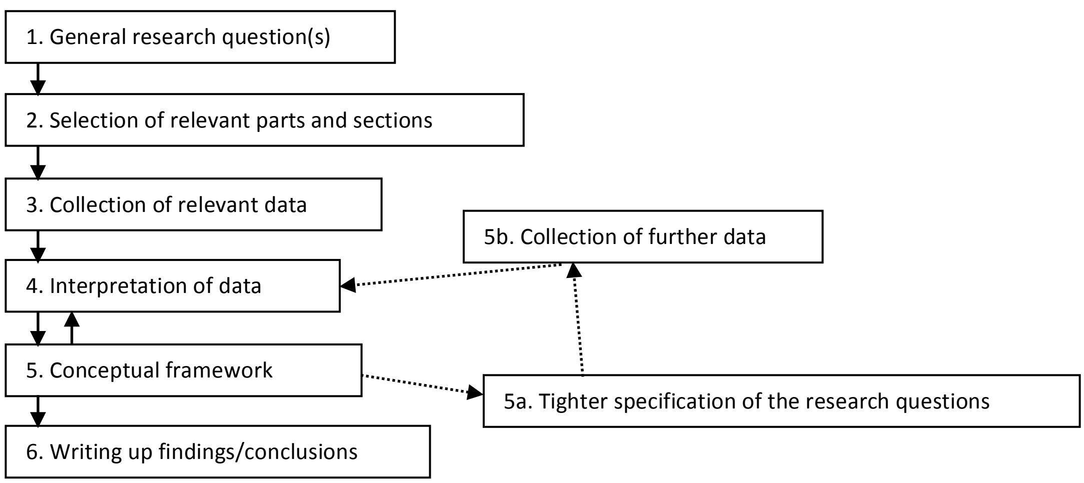

Figure 1. An outline of the key steps of qualitative research

Source: Amended from Bryman, 2012, p. 384.

On 'Technology as Object'

By means of the research procedure mentioned above, the study concluded that NZC, together with TCS, presents an adequate package about the 'object' side of technology's nature; a package regarding, as noted by Mitcham (1994), "… the most immediate, not to say simplest, mode in which technology is found manifest, ... [including] all humanly fabricated material artefacts whose function depends on a specific materiality as such" (p. 161).

The concept of *dual nature*, in terms of both the *physical* and *functional* natures of artefacts, has been explicitly considered within the *Characteristics of Technological Outcomes* sub-strand (see, Ministry of Education of New Zealand, 2010, pp. 37-42). Even the matter of *interrelation* of those two natures has received particular attention within this curriculum:

> Understanding this relationship is crucial when undertaking technological practice to develop a technological product or system for a specific purpose. This understanding allows technologists to recognise that several potential options exist for an outcome's physical and specific functional nature. … the functional nature requirements will set boundaries around the suitability of proposed physical nature options, and the physical nature options will set boundaries around what functional nature is feasible for a technological outcome at any time. (Ministry of Education of New Zealand, 2010, p. 38)

It might initially seem that it is the *Technological Products* sub-strand that points to products' *objectness*. However, that sub-strand has concentrated on the *materialness* of products and the *objectness* of them is regarded, instead, through the *Characteristics of Technological Outcomes* view.

The next point is the latter sub-strand's specific attention to different aspects of *function*, that is, the prerequisites of artefacts to be able to carry out some *function*(s), or even to contain the potential for malfunction(s). (Ministry of Education of New Zealand, 2010, pp. 37-42)

NZC also yields an appropriate, though somewhat implicit, understanding of artefacts' *specific design* in the light of discussing their dual nature: the design element of artefacts is related to both their physical and functional natures as well as their interrelation. This approach emphasizes the significance of the 'physical-functional' interrelation in acquiring a suitable understanding regarding "how physical and functional factors were prioritised in the design and development of an outcome in order for that outcome to be considered fit for purpose" (Ministry of Education of New Zealand, 2010, p. 38)

The notion of *systems* has been extensively taken up in the strand of *Technological Knowledge,* which has not only devoted a specific component to technological systems, but also strives to acquaint students with relevant concepts like *subsystems*, *black box*, *control*, and *operational parameters* (see Ministry of Education of New Zealand, 2010, pp. 62-64).

On 'Technology as Knowledge'

The strand of *Technological knowledge* seems to be the place expected to deliver a sound understanding as to the nature of such knowledge – the expectation overtly claimed by the authors of the last version of NZC would be appropriately met through this curriculum and would fit well with Mitcham's perspective in this respect (Compton, 2007).

Such 'fitness', however, is subject to challenge: reflecting on Mitcham's own conceptualization of this side of technology, one can realize that his considerations revolve around subjects such as the following, as related to the nature of technological knowledge:

- Various structures and types of technological knowledge;
- Phenomenology of technical skills;
- Technological maxims, laws, rules, and theories;
- Different bodies of knowledge of technology compared to science;
- Against technology as applied-science;
- The know-how feature of technological knowledge;
- The path of growing technological knowledge process, and the nature of this transformation; and
- Ancient and modern technology, in terms of their different landscapes of knowledge. (pp. 192-208)

Mitcham's approach has roots in an epistemological direction to technology, which has more to do with excavating different features of technological knowledge in a way that strongly conforms to other philosophers' points and opinions in this respect (see, for instance, Kaplan, 2009, pp. 511-551; Meijers, 2009, pp. 23-404; Olsen, Pedersen, & Hendricks, 2009, pp. 49-128; Vermaas et al., 2011, pp. 55-66). This is summarized by Nia and de Vries (2016a) in Table 2.

The approach of NZC's *Technological Knowledge* strand is quite different from that of Mitcham; rather than delving into the nature of such knowledge and describing the various features thereof (as compared to those of scientific knowledge), this curriculum concentrates on explicating some generic concepts of technological developments:

> [it] provides students with a basis for the development of key generic concepts underpinning technological development and resulting technological outcomes. These concepts allow students to understand evidence that is required to defend not only the feasibility of a technological outcome, but also its desirability in a wider societal sense. Within this strand students will be able to develop technological understandings in terms of levelled achievement objectives derived

> from three key components of technological knowledge – Technological Modelling, Technological Products and Technological Systems. (Ministry of Education of New Zealand, 2010, pp. 15-16)

In addition, while the most philosophical reflections in this regard consider the 'know-how' aspect of technological knowledge in much detail, the strand focuses on the 'know that' side (Ministry of Education of New Zealand, 2010, pp. 15-16). It leaves the 'know-how' side to be only slightly covered in the *Technological Practice* strand (Ministry of Education of New Zealand, 2010, p. 15). The latter strand, moreover, touches in only a minor way on the 'interdisciplinary' nature of technology: rather than unfolding the 'interrelation' of science and technology as two different disciplines of knowledge, it mostly elaborates on the interrelation of various technicians and engineers of dissimilar disciplines in collaborative technological practice (see, e.g., Ministry of Education of New Zealand, 2010, p. 44).

In the same vein, one can see that the other features of the nature of technological knowledge, as well, have barely been taken into account in New Zealand's policy document; only the notion of *creativity* has been slightly considered in the *Nature of Technology* strand (see Ministry of Education of New Zealand, 2010, p. 44).

On 'Technology as Activity'

This aspect of technology is mostly explored throughout the *Technological Practice* strand, which aims to provide suitable knowledge as to what occurs or should be done during various steps of technological processes.

Technological processes are expounded that have generally defined plans, especially in today's technologically complex activities. These plans, in the broadest view, begin with recognizing the *needs* or realising the *opportunities* and proceed through various, not necessarily linear, increments and processes, such as *modelling*, *designing*, *evaluating*, and *developing*. Most of such concepts are given due attention within the *Technological Practice* strand (see Ministry of Education of New Zealand, 2010, pp. 18-36); however, this study, as outlined in Figure 1, showed that there remain some significant issues to be (re)considered in this regard.

First of all, a substantial critique can be raised against the curriculum's approach to *models* and *modelling* (in terms of the nature of models and various ways of designing or making use of them in technological activities), which is discussed mainly in the *Technological Knowledge* strand. Regardless of such an articulation, the subject of *models* and *modelling* is not considered in a comprehensive manner in this strand and is confined to some brief discussion about various types of models and only two types of modelling: "functional modelling [which] allows for the ongoing testing of design concepts for yet-to-be-realised technological outcomes … [and] … [p]rototyping [which] allows for the evaluation of the fitness for purpose of technological outcome itself … [both types are used] to justify decision making within technological practice." (Ministry of Education of New Zealand, 2010, p. 49).

The philosophical reflections, however, deliver extensive descriptions that, as highlighted by Nia and de Vries (2016b), are worth considering in technological literacy programmes. Morrison and Morgan (1999) and subsequently Boon and Knuuttila (2009) have made prudent attempts to release 'models' from the customary perspective of considering them to be merely *representational* tools – the perspective which, by the same token for NZC and TCS, sees *modelling* merely as *representing a reality* (Ministry of Education of New Zealand, 2010, pp. 16, 49). In Boon and Knuuttila's view, models have a broader *epistemic* nature, and modelling is used "to understand, predict or optimize the behaviour of devices or the properties of diverse materials, whether actual or possible" (p. 693). Hence, after a wide investigation into different accounts regarding the nature and various properties of models, Nia and de Vries (2016b) argue that these tools should be considered as *techno-scientific artefacts* with their own dual nature – *intrinsic* and *intentional*. Their well-categorized framework sketches the nature and different features of models and emphasizes their multifunctional roles in *modelling* activities, far from confining them to only a few functions (Figure 2). That study ironically also opens a way to apply its framework to New Zealand's long-term policy document, through delivering a preliminary conclusion that:

> The case … does not give a notable clue delineating the essence of models, … and seems to be [merely] confined to speaking of 'functional models' and 'prototypes'; both can be assigned to [only] the 'decisional' space of the 'communicational' function of models. (p. 24)

Turning to the other notions, one can see that the notions of *innovation* and *invention* have not been given any notable consideration within New Zealand's curriculum, although a deeper level of analysis may reveal some implicit support of such concepts throughout the curriculum. Furthermore, the concept of 'use plan' also has no place in this case. NZC's focus on 'plans' has mostly to do with 'planning for practice', in order to support successful development of technological outcomes (Ministry of Education of New Zealand, 2010, pp. 24-25) – not with various aspects of 'the process of using' artefacts, as in the meaning of 'use plan' that is extensively explained by Mitcham (1994, pp. 230-240) and other philosophers such as Vermaas et al. (2011, pp. 5-20).

On 'Technology as Volition'

Through explorations of the *Nature of Technology*, students come to perceive the volitional aspect of technological artefacts. They become familiar with *the social construction* account of technology, and learn to examine various societal facets of technological volition appearing in interrelationship with notions such as *culture*, *environment*, *politics*, *economics*, etc. (Ministry of Education of New Zealand, 2010, p. 37-48). Such an approach, though not very explicit:

> rests upon a sociotechnological stance which … views as inseparable the complex interweaving of the technological and sociocultural aspects of any technological development … and indeed the specific political and historical context of its development and placement. (Compton, 2007, p. 10)

The same holds true for the *ethical* and *value-related issues* which lie not only in the strand of *Nature of Technology* but throughout the whole document (Ministry of Education of New Zealand, 2010, pp. 96-99). This manner of education leads subsequently to the notion that 'value' should be given appropriate consideration in teaching about *design*, even if not mentioned exactly in terms such as v*alue-sensitive design*.

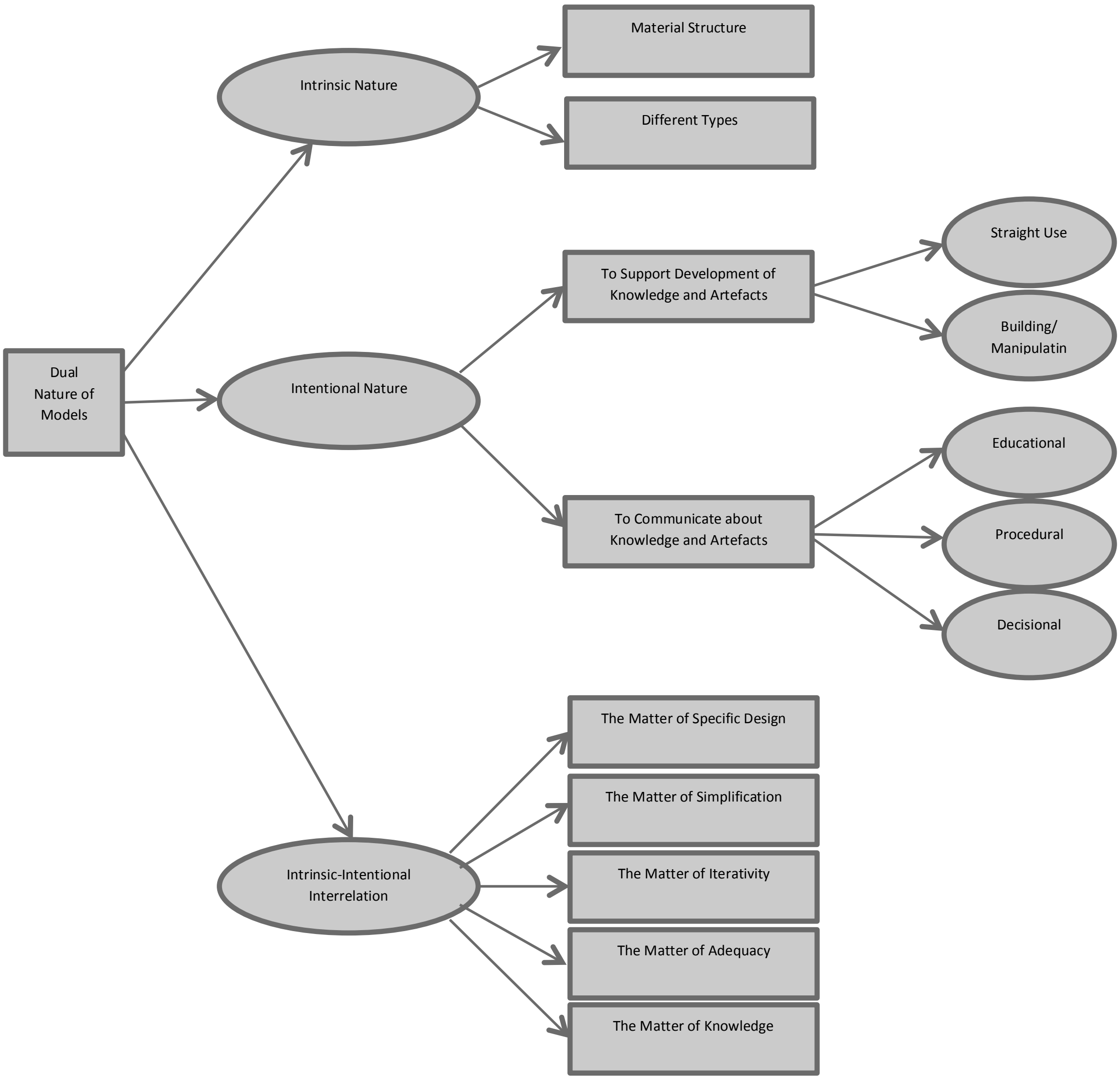

Figure 2. Dual nature of models in a brief sketch
Source: Nia & de Vries, 2016b, p. 24.

Another notable point is that this curriculum does not insist on paying particular attention to various *contexts* of technologies such as *medicine*, *agriculture*, *energy*, *information*, *transportation*, and so forth – an approach in contrast to that of cases such as the American Standards for Technological Literacy (ITEA, 2007), which has dedicated an independent chapter to discussing many such contexts (see ITEA, 2007, pp. 140-197). The approach of NZC is attributed to its preceding experiences of both classroom practice and research, clearly showing "that learning in technology often goes across a number of technological areas and contexts and beyond those named" (Compton, 2005, p. 2)

Eventually, concerning the concepts ignored in NZC and TCS, it is difficult to ascertain any useful consideration on notions such as *aesthetics*, *metaphysics*, and *the future of humanity*. These notions deal mostly with the social aspect of human life and, hence, have been taken into serious account in recent literature of the philosophy of technology (Nia & de Vries, 2016a).

Overall Results

The discussion above can be represented through Table 3. This table can also provide a holistic view as to the state of various aspects and features of technology within New Zealand's curriculum, compared to the claim by its main authors.

As seen in Table 3, 'technology as object' is covered well by the curriculum, but not only via the strand of *Nature of Technology*; the notion of 'systems' is discussed in *Technological Knowledge*. On the other hand, the strand of *Technological Knowledge* itself does not deliver much in the way of philosophical reflections on this aspect of technology. The state of 'technology as activity' can be seen as in between: some concepts are touched upon appropriately, and some require more serious contemplation. Lastly, most volition-related features of technology have been considered through the strand of *Nature of Technology*; there are only a few notions that are not captured.

Table 3. The state of different aspects of technology in NZC and TCS.

Aspect of technology	View		
	Published authors'	This research	
Object	Addressed via *Nature of Technology* – specifically in terms of the *Characteristics of Technological Outcomes*.	Artefacts (as objects)	Adequately considered within *Nature of Technology*
		Systems	Adequately considered within *Technological Knowledge*
		A (specific) Design	Adequately considered within *Nature of Technology*
Knowledge	Addressed via *Technological Knowledge*	Representation of knowledge and skills	Barely considered
		Normativity of technological knowledge	Barely considered

		Interrelation of science and technology	Barely considered
		'Know-that' and 'know-how'	Slightly considered within *Technological Practice*
		Creativity	Slightly considered within *Nature of Technology*
Activity	Addressed via *Technological Practice*	Designing	Adequately considered within *Technological Practice*
		Evaluation	Adequately considered within *Technological Practice*
		Modelling	Slightly considered within *Technological Knowledge*
		Innovation & invention	Barely considered
		Needs, wants, & demands	Adequately considered within *Technological Practice*
		Use plan	Barely considered
Volition	Addressed via *Nature of Technology* – specifically in terms of the *Characteristics of Technology*	Artefacts (as volition)	Adequately considered within *Nature of Technology*
		Value-sensitive design	Adequately considered within *Nature of Technology*
		Ethics, values, & moralities	Adequately considered within *Nature of Technology*
		Aesthetics	Barely considered
		Social construction of technology	Adequately considered within *Nature of Technology*
		Sociotechnical systems	Adequately considered within *Nature of Technology*
		Different contexts of technology	Barely considered
		Technology & metaphysics	Barely considered
		Technology & politics	Adequately considered within *Nature of Technology*

	Technology & society	Adequately considered within *Nature of Technology*
	Technology & culture	Adequately considered within *Nature of Technology*
	Technology & economy	Adequately considered within *Nature of Technology*
	Technology & environment	Adequately considered within *Nature of Technology*
	Technology, future, & humanity	Barely considered

Concluding Remarks and Recommendations

This article commenced with questions about the New Zealand Curriculum approach to technological literacy, namely, does this document provide a suitable path for learning about the nature of technology, and more specifically, does such an approach satisfy Mitcham's perspective in this regard as claimed by its main developers?

An attempt to address those questions was made in this article through a philosophy-of-technology based analysis. Nia and de Vries's (2016a) method was used as an appropriate tool for that purpose, a tool based upon a compilation of Mitcham and other philosophers' opinions as to the nature and features of technology. The findings then unveiled some issues in the New Zealand curriculum. These issues were:

- NZC's approach to categorizing different aspects of technology does not entirely conform to Mitcham's perspective as explained by him and many other philosophers; rather, in some places it presents its own interpretation of such a perspective and can therefore be subject to substantial reconsideration in this regard; and
- In addition to many important concepts that are well covered by NZC and soundly elaborated by TCS, there still exist some features that are entirely missing or, at least, not appropriately discussed through those documents; these need consideration, as captured by Table 3, to provide a more comprehensive package of technological literacy.

Improvement Proposals

The final contribution of the present research is its recommendation for a preliminary schema for amending the issues raised. Developing subsequent, more detailed, and applicable suggestions will certainly demand further study.

The proposed amendments – developed on the basis of the aforementioned discussions and analyses – can be sorted into two categories: those pertaining to the *structure* of NZC, and those pertaining to the *content* of such a structure.

Regarding the *structure* of NZC, it would align more with Mitcham's perspective with the following modifications (as shown in Figure 3).

- It is proposed to make T*echnological Modelling* a sub-strand of *Technological Practice.* As discussed earlier, 'modelling' (as intended in NZC) has more to do with the field of various activities carried out in the course of engineering practices, and has much less to do with reflections from the epistemological view of *Technological Knowledge*.
- The *Technological Products* sub-strand, as it deals with the 'dual-nature' subject, appears consequently more suitable for merging into that of Characteristics of Technological Outcomes. The same is suggested for *Technological Systems*.
- It is strongly recommended that some sub-strands with an epistemological approach to the nature and different features of technological knowledge be embedded into NZC (the required content for such a sub-strand can be seen in the discussion immediately below).

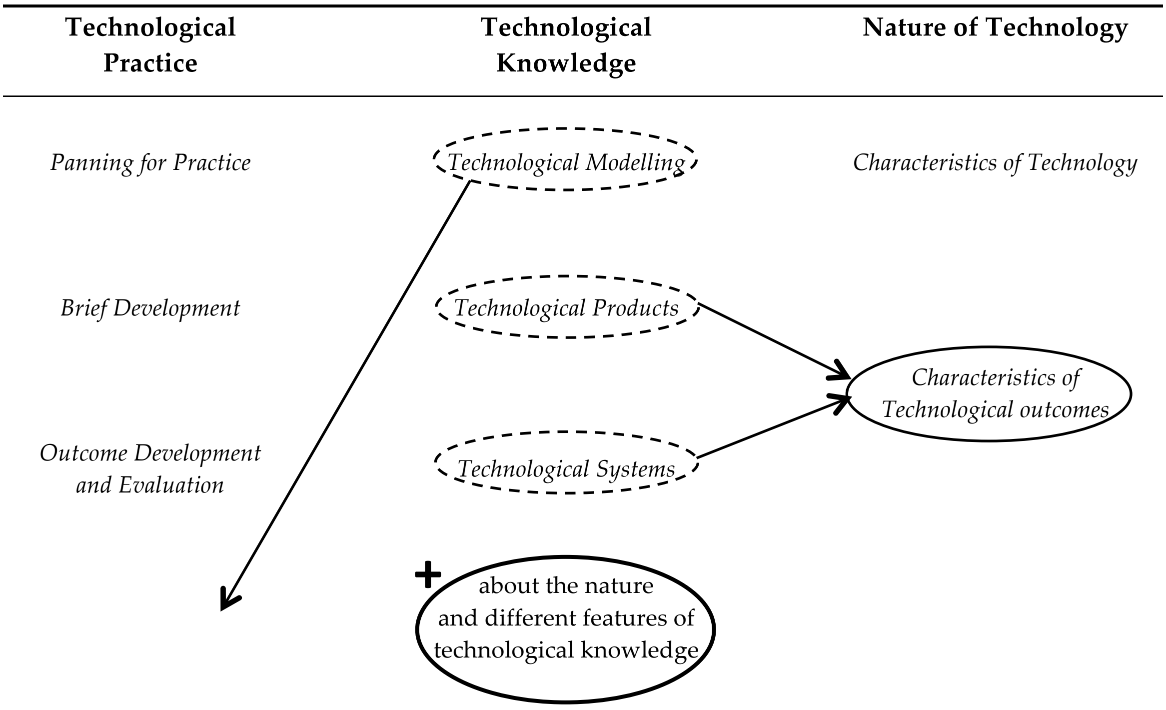

Figure 3. Restructuring proposal for NZC

In terms of *content*, there are certain concepts, summarized in Table 3, which are barely or inadequately considered in NZC. Such concepts should be embraced more fully and explained in the appropriate places in both NZC and TCS.

- *Technological Knowledge* needs to be touched upon from a more epistemological perspective (compared to the current approach of relating it to different attributes or functions of 'models', 'products', and 'systems'). It should be discussed in terms of the various features of such knowledge, its 'know-how' aspect (as opposed to 'know-that'), 'normativity', and key 'distinctions' and 'interrelations' with scientific knowledge.

- *Technological Activity* should cover concepts such as 'innovation', 'invention', and 'use plan', as they are notions that play a pivotal role in most engineering processes. In addition, the concept of 'modelling' (including 'models') could be discussed much more than it currently is in both NZC and TCS.
- It is strongly suggested that *Nature of Technology* – more specifically, its *Characteristics of Technology* component – devote some space to acquainting students with the 'aesthetic' and 'metaphysical' sides of technology's nature, as well as 'future trends' in terms of how to deal with it or have an effective role in making it.

Finally, the significant point is that this package of proposals does not claim to be a perfect one for improving the quality of NZC, nor is the suggested method believed to be the best in utilizing the philosophy of technology. Rather, the intention of this article is to address certain challenges and opportunities embodied in the approach of the case studied, so that it could deliver a more comprehensive understanding about the nature and various features of technology. With this said, the presented analysis can itself be subject to necessary enrichment in terms of providing more from the discipline of the philosophy of technology to be used in technological literacy attempts. Moreover, the aforementioned analysis can be considered further in more detailed studies. The aim is for such proposals to lead to more effective material and the conclusions to be embedded in the existing approach in a consistent and effective way.

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