Journal of Technical Education

Band 1, 2013, Heft 1

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Herausgeber

Bernd Zinn

Ralf Tenberg

Journal of Technical Education (JOTED)

ISSN 2198-0306

Online unter: http://www.journal-of-technical-education.de

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Abstract

Learning concepts is an important domain within technology education. Not much research has been spent on it, unfortunately. Also it is not clear, how concepts can be learnt. In this paper some ideas about that will be presented. In particular the role of design as a pedagogical strategy will be highlighted.

Keywords: concept learning, artifacts, structure, function

Konzeptionelles Lernen in der technischen Ausbildung

Zusammenfassung

Konzeptionelles Lernen ist ein wichtiger Bestandteil der technischen Ausbildung. Leider stand dies bisher nicht im Fokus der bisher durchgeführten Forschungsaktivitäten. Auch ist es unklar, wie die Konzepte erlernt werden können. In diesem Essay werden einige Ideen zu dieser Thematik vorgestellt. Vor allem wird die Rolle einer pädagogischen Strategie besonders fokussiert.

Schlüsselwörter: Lernkonzept, Artefakte, Struktur, Funktion

1 Introduction

For a long time, learning concepts were not seen as something relevant for technology education. Technology education in many countries grew out of a craft-oriented subjects. More recently, though, an awareness of the importance of a more theoretical, cognitive component for technology education emerged (De Vries, 2009). As a consequence, an interest grew into the philosophy of technology, as it was evident that this academic discipline could serve well as a source of inspiration for building a theoretical framework for technology education (De Vries, 2005).

Some years ago, a Delphi study was done to seek a group of international experts' advice on the set of basic concepts that they thought were most relevant for technology education. The outcome of that study was that the following five concepts were the basic for technology education: design-as-a-verb ('designing'), systems, modeling, resources and values (Rossouw, Hacker & De Vries, 2011). Design-as-a-verb entails such sub-concepts as optimizing, set of criteria and trade-off. The main three categories of resources are materials, energy and information. In this chapter I want to focus on the domain of sub-concepts related to systems, and in particular the sub-concepts of design-as-a-noun (‘a’ design). Another term for this is: artifacts.

2 Artifact-related concepts

Artifacts play a vital role in technology education. Not only they are the outcome of a design activity, but also they are the expressions of technology that we find everywhere around us. Therefore, a good understanding of the nature of artifacts is a crucial component of technological literacy. This term is used since the Nineteen-seventies to indicate the knowledge, capabilities and attitudes that all citizens need to live in a technological world in such a way that they master the technology rather than the other way round. Most of us do not get to see the process of technology (the designing and making). What we are confronted with are the outcomes of such processes, the artifacts. Technological literacy therefore to a large extent means that we should have a basic insight into what these artifacts are and what they do, and how to deal with them in a sophisticated way. In the Delft University of Technology philosophy of technology group, an approach for understanding artifacts has been developed under the title: The Dual Nature of Artifacts. This is an attractive approach from an educational point of view because it very much brings down the understanding of artifacts to the most fundamental components. Once people have developed an understanding of those, we can move on to a more detailed understanding.

In this approach, artifacts are conceptualized by defining two different ways of describing them. Those two ways are not reducible to each other, and the combination of both is necessary to get a full understanding of the artifact. The first way of describing an artifact is its structural or physical nature. It tells us all the characteristics that are inherent to the artifact, such as its size, color, number of parts, weight, mechanical properties, chemical properties, etc. These are the characteristics that do not need a user for their existence. The artifact has them, independently of what we think of them. This is not the case with the other way of describing the nature of the artifact, namely the functional nature. This description is user-dependent. One person may tell that the object on the table is a screwdriver; another person may claim that it is a paperweight. This nature does not tell us what the object actually does, but what it is supposed to do. Even when a screwdriver is on the table, idle, it is still a screwdriver. The car in the garage is still a car, even though it cannot take us from A to B, which is the reason why we call it a car.

Designers know by experience that one description of the artifact cannot be derived from or reduced to the other. That is the case because there is more than one way to realize a desired functional nature in a designed structural or physical nature and vice versa one structural or physical nature can be used for realizing very different functions. What designers do is reason back and forth between the desired functional nature, as expressed in the list of requirements, and possible structural/physical realizations. In order to do that they need at least three types of knowledge (De Vries, 2006): knowledge of the structural/physical nature (e.g., knowledge of shape and material properties), knowledge of the functional structure (e.g., knowledge of what it means for an artifact to be a photocopier), and knowledge of the relations between structural/physical and functional nature (e.g., knowledge that this material/shape is suitable for that function).

3 Learning about artifacts

One of the problems we face when teaching about artifacts is that we do not know much yet about pupils' preconceptions. How do they see artifacts? Do they have some awareness of the two sides of artifacts as we described them above? Or do they, perhaps, intuitively only recognize one of these sides; and if so, which one is that? The same questions can be asked concerning teachers: how do they see artifacts (Frederik, Sonneveld & De Vries, 2011)? Questions like this are very relevant when we believe that all learning is somehow reconstructing beliefs that we hold because we learnt them 'on the street'. If we ignore such 'street images' and only add a 'school image' next to that, there is a fair chance that pupils will behave nicely in school and talk about artifacts as we tell them, and as soon as they are back on the street they fall back into their intuitive beliefs. There is ample research in science education that showed that this is likely to happen when we fail to create cognitive conflicts in which the 'street image' is confronted with reality and fails to work. This does not mean the 'street image' is always wrong. There are good reasons why we hold it, due to the fact that it works for most of everyday's life situations. That should make us a bit more prudent in using the word 'misconception' to identify such practice-based intuitive notions. They fail, however, when we want to apply them to a wider variety of situations, and this is precisely the purpose of theoretical concepts, both in science and in technology.

Learning concepts has been proven to be difficult. That is understandable because we never see these concepts in practice. One of the systems in the Delphi research list was 'systems'. What we see is cars, mobile phones, computers and buildings - not 'systems'. It takes time for us to learn that all the artifacts we see around us have certain characteristics in common that we use to define a concept called 'system'. Even when we know, what a 'system' is, it is sometimes hard to recognize it in a concrete artifact, because in each and every artifact this concepts takes somewhat different shape, because the characteristics, that are common for all systems are then mixed with characteristics, that are specific for the car, the mobile phone, the computer or the building. Learning concepts therefore require that we learn to separate the common characteristics from the context-specific characteristics. One could illustrate that by using the metaphor of the chameleon. First time we meet one, it sits near the water and is blue. So we develop the idea that the chameleon is a blue animal with a long tongue. The next one we see sits in the grass. We do not recognize it as a chameleon as it is not blue. Yet it does have the long tongue. Then we see a third one on a red tiled roof and it is red, but has this same long tongue as the previous two had. Gradually we start realizing that it is the tongue rather than the color that makes the chameleon a chameleon. Once we know that, we recognize more easily that the grey animal sitting on the asphalt road with the long tongue is again a chameleon.

4 Design as a pedagogy for teaching about artifacts

One pedagogy that is particularly rich for learning about artifacts is designing them. In the first place, designing offers opportunities for create cognitive conflicts between intuitive beliefs and technological knowledge. When I design my boat based on wrong beliefs about floating and sinking, and my boat sinks, obviously there is something wrong with my 'street image' and my motivation to get the boat floating makes me prepared to rethink these intuitive notions, I have held so far. In the second place, in design situations, I never use the concept in isolation, but always in combination with other concepts. That means that what I learn is a network of concepts rather than a set of isolated concepts, and that is exactly what we want in education. In the third place, designing is a basic concept itself that is also worth learning in technology education, so I strike two aims in one time. Fourthly, a series of design activities allow to see the same concept in different contexts. Then it serves as what is called a 'practice' in the concept-context approach, that says that concepts should be learnt in a series of concrete contexts and the best contexts are those, in which pupils are engaged in activities that make sense to them. Design activities can be such activities, when properly chosen.

5 Conclusion

Learning about artifacts is an important element in technological literacy. The most basic way to get to know artifacts is to recognize their structural/physical nature and their functional nature. In design activities we learn to link the two natures. When properly arranged design activities can stimulate a deep and versatile understanding of artifact-related concepts. Educational research is needed to find out how this can be realized best.

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Zitieren dieses Beitrages:

De Vries, M. J. (2013): Concept learning in technology education. Journal of Technical Education (JOTED), 1(1), S. 147-151.