Promoting Technological Thinking

The Objective and the Means

Antti Pirhonen

Technological thinking is not a discrete form of thinking. Whether we talk about the use or the development of technology, technological thinking intersects with logic, creativity and many other human qualities. The bare definition of technological thinking is an ambiguous task, not to speak of the wide variety of attempts to promote it in education. In this paper, we do not aim at saying the final word about the appropriate means of promoting technological thinking. In the contrary, our aim is to analyse some ideas which are commonly proposed as such means but which can be argued to conflict with contemporary understanding of human thought. Our approach draws on the phenomenology of the body. The focal claim is that human action is thinking rather than reflection of it. This claim underlines the importance of physical activity as the fundamental characteristics of human existence. In the promotion of technological thinking, this implies that there is no technological thinking without physical experiences on which concepts, problem solving and design could be based. In the educational context, providing an environment for rich interaction with physical objects would be essential. In the era of digitalisation, schools appear to be eager in substituting real learning environments and technology with their virtual counterparts. From the point-of-view of embodied cognition, this trend can be seen as a severe threat to the development of many abilities which are central in technological thinking

Keywords: Embodied cognition, technological thinking, education, extended mind, cognitivism, identity

Introduction

Technological thinking is an ambiguous concept. To define it, even for the needs of a single research paper, is amazingly tricky. We lack wide agreement about the content of "technology", let alone "thinking".

In this position paper, we do not aim at providing an exhaustive definition of technological thinking. That is due to the fact that both technology and thinking as concepts are firmly bound to the paradigms which they represent. The existing confusion can be seen to be caused by the habit of using terms of colloquial language when actually referring to a more or less theoretical phenomenon. Thinking, in particular, is a word which we all use in everyday context. However, when referring to a certain kind of cognitive process, using the same word is risky: the colloquial connotations may be unintentionally associated with it. We therefore start this paper with a description of what we mean by technological thinking and how it relates to a more generic philosophical framework.

Technological thinking and human cognition

Human cognition is commonly associated, if not equalled, with the concept of thinking. However, different views of cognition, both of its domain and of its content, vary a lot. In the time when Cartesian dualism was the dominating way of understanding human nature, human thought was located in the skull. All observable phenomena of human behaviour were seen as reflections of the processes which had taken place in the brain.

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Along with the empirical findings in neuroscience and philosophical reasoning about the fundamentally corporeal basis of human cognition, we have been challenged to build a more holistic view of human being than the one applied for the last few centuries. If we accept the contemporary embodied cognition thesis (Varela, Thompson & Rosch, 1991), we should be able to express what it implies in e.g., technology education and technological thinking. In addition to embodied cognition, we apply the notion of extended mind (Clark & Chalmers, 2010) as a framework in this paper.

Given that the design of technology implies qualities like creativity and problem solving, the adopted paradigm of human cognition is the cornerstone of the activity. The choosing of the appropriate paradigm does certainly not imply a random selection of theoretical framework. Since paradigm denotes the perspective to the phenomenon in focus, vocabulary and even prospective observations, it is essential that it is relevant. Therefore, we argue that in the endeavour of enhancing technological thinking embodied cognition is a sound and up-to-date basis, this time complemented with extended mind thesis.

In the paradigm of embodied cognition, human thought is not only based on bodily experiences but it can be argued that thought takes place in the body. As we have argued elsewhere (Pirhonen, 2018; Pirhonen, 2019), the basis of human conceptual system is corporeal. I.e., the roots of our concepts are deep in bodily experiences. Hands, for instance, are not some sort of peripherals of human cognition but very central constituents of it.

If technological thinking is seen as interaction with the environment and manipulation of it, the promoting of technological thinking thus inevitably implies rich physical interaction with diverse materials.

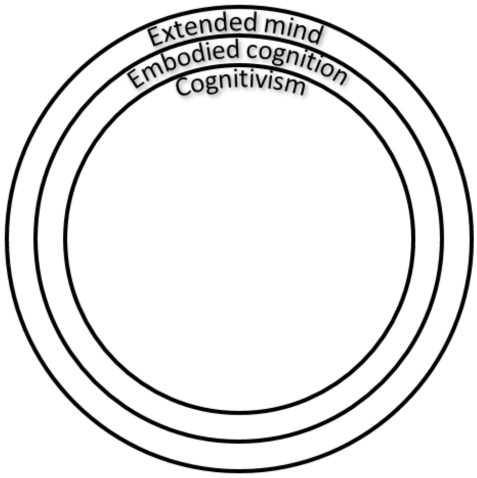

Figure. The domains of different paradigms of cognition.

The description above concerns the application of embodied cognition to technology education. Indeed, the embodied cognition thesis embraces whole human being in the analysis of thought.

In order to understand the concept of cognition and how embodiment is related to it, we illustrate different paradigms of cognition in terms of their domain. In other words, we are trying to figure out which phenomena are counted as constituents of cognition in different paradigms. Since different paradigms are – by definition – incommensurable (Kuhn, 1970), we will need to over-simplify things slightly. Our view is illustrated in Figure 1. To some extent, the figure also illustrates the chronological development of the idea of human cognition. We now briefly describe this continuum, from the point-of-view of the development of technological thinking in particular.

Cognitivism

In the core of the figure is cognitivism, the paradigm which was seen as a reaction to behaviourism. When behaviourism aimed at constructing a view of human being solely on the basis of outer, measurable behaviour, cognitivism turned the focus to inner phenomena. For cognitivists, human thought took place in the brain. Outer behaviour was arguably reflection of cerebral activity, based on sensation. In other words, human cognition was seen as a computer, consisting of input (senses) and output (e.g., muscular activity) "devices".

In the cognitivist view, technological thinking is mental activity, which is fundamentally possible to be explained in neural level. Design and use of technology are based on neural structures. In technology education, the object of education is thus to develop that kind of neural or "mental" structures. The physical activity – not to speak about material – have instrumental value only in the process of developing "knowledge".

In the practices of technology education, cognitivist view appears to be strong. In the pedagogical discourse the emphasis is in the process in the cost of physical outcome, thus reflecting this view in which the focus is in the invisible cerebral phenomena.

Embodied cognition

Embodied view of human cognition rises to the challenge which computational view of human cognition failed to explain: the observed intimate relation between the mind and the body. Based on the seminal work of phenomenologists e.g., Edmund Husserl, Martin Heidegger and Maurice Merleau-Ponty, the contemporary theory of embodied cognition denies the Cartesian dichotomy of mind and the body (Rowlands, 2010). In the different versions of embodied cognition doctrine, the primacy of corporeal experiences in human cognition is expressed in a variety of ways.

In stressing the importance of the body in human thought, the application of embodied cognition in technology education and the promotion of technological thinking should be uncontradicted: Thinking implies doing (see e.g., Depraz 2013). In the context of technological thinking, the physical activity becomes exceptionally clear. The ability to think, solve technological problems, manipulate the environment and interact with it, are all embodied phenomena. Therefore, the mission of technology education can be seen as to provide an environment, which enables rich interaction with different materials (Pirhonen, 2018).

The contrast of embodied view of cognition and cognitivism is drastic. Embodied view expanded the domain of cognition from cerebral processes to human action; from the brain to the whole body. It can be argued that this paradigm shift largely concerns the whole view of human being. Here, however, we focus on the implications for technology education. In technology education, embodied view nicely stresses what is actually being done – whereas cognitivist view stresses something that cannot be sensed but rather something that should be believed in.

Extended mind

When further expanding our conception of the domain of cognition, we can easily find the borderline between us (as embodied, cognitive creatures) and the items which we use in cognitive tasks, being quite fuzzy. In the embodied view, our whole body constitutes our cognition. Let us think about our vision and our eyes: If our eyes are part of our cognition, how about our spectacles? Or if a person with difficulties with memory, uses pen and paper for notes – what is the difference between memorising – or mental note – and a physical note?

As a form of externalism of mind, Andy Clark (2008, Clark & Chalmers, 2010) proposes a concept of extended mind. He makes a distinction between generic externalism and what he calls active externalism, when formulating this theoretical construction. Put it simple, he denies the sharp borderline between the inner and the external.

The extended mind thesis, when understood as an extension of embodied cognition, is highly relevant when dealing with technological thinking. The process of technological problem-solving, for instance, typically includes not only physical activity of the agent, but also the functions of tools and materials. As such, extended mind thesis can be argued to complement the embodied cognition thesis to be valid in technology education.

Extended mind thesis can and should be exposed to critical scrutiny, for sure. For instance, Clark does not problematise the roles of human agent and the tools in the interaction with the environment. Assigning a cognitive task to an external device is not a simple externalisation of unwanted effort. That kind of naïve idea of making life easier by letting the machines do the dirty work, might have been relevant in the past. Indeed, the rise of standard of living used to go hand-in-hand with the development of technology for centuries. However, that tendency changed a few decades ago (see e.g., Pirhonen, 2019). The reduction of physical effort, which first resulted in e.g., health benefits, has gone too far and we now need to substitute the vanished work-related efforts with artificial ones. We are bound to face the same kind of phenomenon with mental efforts: In the days of computer metaphor of human mind, our cognitive system was seen as a relatively stable one with limited resources. By externalising e.g., memorising to a machine, we expected more mental resources to be available to other tasks. However, once the malleability of our cognitive system has been understood (Carr, 2010), it would be appropriate to replace the computer metaphor with a muscle metaphor: if the brain is not used, it gradually loses its capacity.

We argue that the extended mind thesis as an extension of embodied cognition is an appropriate and important framework in the discussion about the development of technological thinking. Despite its deficiencies it provides an approachable and highly relevant framework for the needs of technology education.

Implications in technology education

The impact of the adopted paradigm of human cognition has straight forward impact in our conceptions of learning and teaching, thus in pedagogy. Or at least should have. Technology education is a very interesting subject to be analysed from the paradigm-perspective. Schools are not usually built nor teachers educated to be ready to reflect the changing conceptions of learning and teaching. They reflect their own era and the culture from which they originate. Technology education is a relatively new content area; therefore, the organisation of technology education should be based on contemporary educational philosophies.

How is it, though? Once the importance of e.g., bodily experiences and manipulation of materials has been found, have schools been eager in promoting technological thinking by providing opportunities for exploring the world of matter? It is impossible to give a generic answer. There have always been teachers who have understood the importance of technological thinking, in other words, the ability to actively interact with the surrounding world. Then there have always been teachers who have adopted the Cartesian (or cognitivist) view of human being and think that the ultimate objective of schooling is to influence cerebral structures. In the current era, these two conflicting views are clearly present. Unfortunately, the latter appears to get much more popularity among policymakers. In practice, this means that the facilities in schools rarely encourage to really do things; explore, experiment and feel.

Nowadays technology education is frequently associated to digital technology. Encouraging schools to apply digital technology in various forms is probably seen as promotion of technology education. However, how does digital technology in the current form support the development of technological thinking? For instance, using a fashionable example, how does a 3D-printer relate to the embodied view of human cognition? To our understanding, current view of human learning stresses immediate experiences. This has probably been best understood in early childhood education (e.g., Robbins, Jane & Bartlett, 2011). The more technological products we apply in making, the further away we are from the actual material. If a pupil designs an item in virtual reality and then a 3D-printer realises it, there is necessarily no immediate interaction between the pupil and the physical process.

We conclude that if the thesis of embodied cognition holds true, ICT-mediated design and making is not an ideal strategy in terms of creativity nor learning. For the same reason, technological thinking does not necessarily benefit from the use of ICT. The problem of ICT from the point-of-view of technological thinking is that in ICT-consumer products most of the technology is intentionally hidden. They are not designed to make technology visible and understandable – they are typically designed to offer illusions and pleasure.

Conclusions

In Figure 1, we presented a simple illustration about the relationship among three different paradigms of cognition. The figure was supposed to tell how our understanding about human cognition has gradually expanded from brain-centred view to body-centred and beyond.

In the context of technology education, a nice theoretical framework is not an end in itself, though. As any theory, it should be scrutinised and exposed to criticism. However, even if it would stand the academic pressures, it has to be relevant in the educational context, too. In that sense, we argue that it is relevant but incomplete. Namely, in the most extensive of the paradigms presented – extended mind thesis – some essential points of education are still left aside. Above all, the extended mind thesis still handles the physical objects, even those counted as constituents of cognition, as functional entities, something that are used for something.

In school context, the idea of physical objects as instruments or tools for something, is deficient. We refer to the stereotypical setting, in which something new is constructed by a pupil. A teacher with cognitivist view focuses in the construction process and she is convinced that something valuable happened in the mind of the pupil during the construction process. A teacher with embodied view believes that the physical activity during the construction was the essence of learning. A teacher who has adopted the extended cognition paradigm, values not only the invisible cerebral processes (like her cognitivist colleague) and the observed physical activity (embodied view), but also the physical object which is the outcome of the activity.

Experienced teacher may tell that something is missing from this continuum. Namely, even if we would acknowledge the cerebral, bodily and physical (instrumental) aspects of the construction process, we don't have a framework for understanding pupil's devotion to the item she designed and made. Extending the metaphors used in the extended cognition thesis, could we interpret that the physical outcome of creative process becomes not only part of pupil's cognition, but part of her identity?

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Antti Pirhonen is an educationist and computer scientist by background. He is an Adjunct Professor of Interactive technology in the University of Tampere, Finland, and an Adjunct Professor of Learnability & user-interfaces in the University of Jyväskylä, Finland. He holds PhD in Educational Science and in Computer Science. He is currently employed by The Finnish Institute for Educational Research (FIER).