A pragmatist theory of learning

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Abstract. This paper suggests that Peirce's pragmatism might be a more suitable underpinning of educational research than the currently prevailing constructivism, in particular with respect to science and mathematics education. Using examples from the educational literature, a case is made for a notion of "truth", a pragmatist scientific method, Peirce's doubt-belief cycle and his semiotics and logic in relationship to educational theory. This paper does not present any in-depth discussion of philosophical issues but attempts to highlight the need for a better philosophical foundation of educational research in the hope of encouraging future research in this direction.

1 Introduction

Constructivism has been the leading educational theory of the last 20 years (Phillips (1995), Matthews (1993)). For example, Ben-Ari (1998, p. 46) cites Ernest saying that "radical constructivism represents the state of the art in epistemological theories for mathematics and science education". In some cases the idea of constructivism is restricted to viewing learning as active creation of mental structures without making any philosophical claims. This has successfully initiated a shift from lecture-centric teaching to pedagogical methods that aim at teaching for understanding, encourage interactive engagement of the learner and investigate the social and cognitive nature of learning.

In other cases, however, educational researchers advocate philosophical (radical) constructivism as well. While this may not pose a problem in disciplines such as the humanities where knowledge is somewhat relative by nature, we are claiming that it is unsatisfactory as an explanation of knowledge in the sciences and in particular in mathematics. There has been some criticism of radical constructivism in the educational literature. For example, Phillips (1995) identifies "the quasi-religious or ideological aspects of constructivism as being ugly". He criticises the emphasis of relativism and the "justification of our knowledge as being entirely a matter of sociopolitical processes or consensus or toward the jettisoning of any substantial rational justification or warrant at all". Matthews (1993) states that "constructivism is basically a variant of the old-style empiricist epistemology, which had its origins in Aristotle's individualist and sense-based theory of knowledge".

In our opinion, Peirce's pragmatism has the advantages of constructivism (emphasising cognitive processes and the social-collaborative nature of knowledge generation) but not the disadvantages because Peirce managed to find a middle way between constructivist, idealist and realist positions. He does explain why mathematics is different from other disciplines and allows for rational justification of knowledge. Therefore pragmatism would serve as a much better foundation for educational theories than constructivism. It is a puzzling question as to why pragmatism has not had any significant influence on educational research so far[1].

Most likely the attendees of this Centennial will be very familiar with Peirce's pragmatism and many will be advocates of pragmatism themselves. Therefore the aim of this paper is not to provide an in-depth analysis of Peirce's pragmatism and its connections to learning or to develop a new theory. The aim of this paper is to highlight the fact that educational theorists still seem to have a problem with pragmatism. This analysis is provided using examples found in the literature of mathematics, science and computing education. Our hope for this paper is that it might encourage other attendees of this conference to occasionally write papers for an educational audience because we believe that an understanding of pragmatism would be helpful in that field.

2 Why is pragmatism helpful for educational research

This section briefly summarises advantages of Peirce's pragmatism as an underpinning theory for educational research compared to constructivism. Peirce's view of science is compatible with the view held by constructivist educational researchers in that science is the result of a social constructive process and that an individual learner must actively create mental structures while learning. Peirce also acknowledges that science is a collaborative process. Nevertheless as explained in the following sections, he also accepts a notion of "truth"; pragmatism provides an improved understanding of what constitutes a scientific method; Peirce's doubt-belief cycle provides a model for scientific thinking; and his semiotics and logic can be usefully applied to educational research.

In the following sections, we are using examples from the literature on science education, interactive engagement teaching and threshold concepts. The examples are from papers which the author encountered while working on an educational project and represent typical examples of what is currently read by educational developers. The main content of these papers is not philosophical, but of educational nature and not relevant for this paper. The philosophical underpinnings of the papers that are highlighted here are usually expressed by the authors only as an occasional side note.

2.1 The notion of "truth"

The first example is a paper by Meyer & Land (2003) who adopt a post-modernist position and question the neutrality of the knowledge that is taught to students: "Whose ... concepts then becomes a salient question". It is correct that in some disciplines (such as the humanities) knowledge tends to be associated with a particular researcher. In

[1] Claims such as this one are based on the experiences the author of the paper has had over the last two years by being involved in a large-scale educational project in Germany. Basically all my colleagues are self-proclaimed constructivists whereas essentially no one has even heard of Peirce or pragmatism.

such fields, teaching often focuses more on skills (analysis, reading skills, literature review, argumentation, modelling, etc.) than on facts. If even scientific and mathematical knowledge was owned by an authority as indicated by Meyer & Land, then how could teachers convince students that they need to learn this knowledge as provided by that authority? As the literature on threshold concepts (Meyer & Land, 2003) shows, learning complex theoretical constructs (in any subject) is a challenging and time-consuming process. In the humanities, students tend to be allowed to analyse and criticise models that were developed by other researchers thus maintain a certain degree of independence and choices. In the sciences, although facts are principally fallible, from a student view there are absolute "right and wrong answers". In mathematics most statements can even be proven to be true or false. Ben-Ari (1998) sees it as one of the challenges of computer science education that "knowledge is not open to social negotiation" in this field.

In our opinion, a constructivist or post-modernist point of view does not provide sufficient justification for why knowledge in the sciences and mathematics does have such a rigid, non-negotiable nature. Ben-Ari (1998, p. 50) states that "absolute truth is unattainable, so there is no foundation of truth on which to build. Even 2+2=4 is not a necessary truth". Many students struggle with science subjects and universities tend to observe high drop-out rates in the first years of such courses. According to a constructivist view, understanding involves making mental constructions. It seems preposterous to force students to construct their minds in a predetermined way (for example learning a mathematical definition) just because other people intersubjectively created this complex knowledge. Furthermore, it would appear that this knowledge could change at any point in time not because new evidence emerged but because scientist changed their consensus.

On the other hand, an external world as a "ground" for scientific inquiry and at least a hope as expressed by Peirce that scientific inquiry approaches truth via an infinite chain of reasoning does provide a justification for why scientific knowledge is the way it is. Without a foundation in reality and an acknowledgement that truth is possible, teachers do not have good arguments for teaching science or for changing the students' attitudes towards science. Gray et al. (2008) argue that one of the problems with science education is that students have entirely different views about the nature of science than experts. Students often believe that, for example, physics is just a random collection of methods and calculations without relevance for everyday life. Thus, students are seeing science as arbitrarily constructed instead of as making statements about reality. Clearly a constructivist educational theory provides no basis for changing the students' beliefs in that respect.

In general, a short-coming of (radical) constructivist educational research is that their framework of analysis is limited by excluding ontological aspects. Ben-Ari (1998, p. 50) states that "ontological reality is either rejected or at best considered irrelevant". But as Sfard (1991) argues when it comes to understanding why mathematics in particular is difficult to teach and learn, it is beneficial to investigate both cognitive but also ontological aspects of the nature of mathematics. Peirce defines mathematics as "the study of what is true of hypothetical states of things" (CP 4.227244) and thus provides a precise foundation for the nature of mathematics.

2.2 The myth of a scientific method?

Constructivists and pragmatists tend to agree that a Descartian scientific method (a cycle of hypothesis formulation and testing conducted by an individual scientist who holds him- or herself to being honest and objective) is a myth. Bauer (1992) states that modern science did not start with Descartes but slightly later with the introduction of scientific journals and peer review. Individual scientists will always make occasional errors but these are detected and corrected during the peer review process. Science is therefore a collaborative endeavour. Unfortunately, Bauer's detailed analysis of why the Descartian scientific method is a myth does not provide an equally detailed description of what this myth should be replaced by. Bauer's own conclusion is peculiar: because the traditional scientific method does not exist he infers that there is no real distinction between pseudoscience and science and therefore pseudoscience is acceptable. A similarly peculiar statement can be observed in an educational research paper by Rountree & Rountree (2009). Their paper is mostly well-reasoned but then suddenly, slightly out of context, they state that "... there is only a limited amount of utility in trying to determine ... concepts by empirical means. Science ... is a social construction: if there are ... concepts ... it is because we have put them in place and made them so." (Rountree & Rountree, 2009, p. 142).

Thus although there is a wide-spread agreement among contemporary educational researchers that a traditional model of a scientific method is a myth, it appears that many researchers have not filled this gap with an adequate new model of how science functions. We are advocating in this paper that Peirce's pragmatic method is such a suitable candidate for a scientific method.

2.3 The doubt-belief cycle

It is of interest to consider Peirce's doubt-belief cycle in relationship to learning. Peirce's views are compatible with constructivist views of learning in that "we cannot begin with complete doubt. We must begin with all the prejudices which we actually have when we enter upon the study of philosophy." (CP 5.256). But as Kasser (1999) observes, according to Peirce the resulting scientific knowledge itself is not psychologistic but instead (and in contrast to constructivist views) independent of psychological, cognitive aspects. Peirce states that "how we think, therefore, is utterly irrelevant to logical inquiry" (CP 2.56).

There appear to be far fewer papers on Peirce and educational theory, at least with respect to teaching sciences or mathematics, than one would hope. A few examples of relevant papers are Levy (2007), Schreiber & Moss (2002) and Smith (1997). Levy (2007) explains that Peirce discussed learning in his writings but did not develop a well-organised, consistent theory of it. Learning arises out of doubt (not being "satisfied with what you already incline to think" (CP.1.135)). Peirce's dilemma for teachers is the problem that teachers must be convinced of the truth of what they are teaching and therefore cannot be in a state of doubt and be learners at the same time. According to Levy, Peirce's way out of the dilemma is that teachers must have strong beliefs but must see beliefs as fallible. Effective teaching implies that the teacher is willing to learn.

Peirce's doubt-belief cycle could serve as a possible explanation for the learning effects observed by Mazur (1996). Mazur uses a learning cycle that starts with a challenging question which is represented as a multiple choice question on which the students vote during the lecture. If teachers follow certain guidelines on how to use this method an interesting effect can be observed. Initially, usually only a small number of students answer correctly. The students then discuss their answers for a few minutes in a peer discussion before voting on the same question again. Usually this time a large number of students answer correctly. Mazur and his followers have shown that this is a successful teaching method. But other than stating that peer discussion helps students in forming required mental constructions there have not been any explanations provided for why this method is successful. In our opinion, this method could exemplify a miniature example of Peirce's doubt-belief cycle which starts with a question that surprises the students and lets them doubt their prior assumptions. The short peer discussion allows for conceptual development which leads to a new belief state as evidenced by the second iteration of the question. Students are learning because in contrast to listening to a teacher-provided explanation, they are actively participating in a miniature example of scientific inquiry.

2.4 Semiotics and logic

Because of Peirce's emphasis on logic and reasoning, his method is not just suitable as a general framework, but also has been validated as a logical framework suitable for modern knowledge representation tasks[2] (including some artificial intelligence applications and the semantic web). In some cases a misunderstanding of Peirce's semiotic chain of meaning results in post-modernist claims. For example following Derrida, Meyer & Land (2003) state that "Moreover, the inherently arbitrary and non-referential nature of language compounds conceptual difficulty through obliging those seeking to teach or clarify concepts to deploy further terms, metaphors and concepts in an endless play of signification." They are thus claiming that teachers have difficulty explaining concepts because signification cannot come closer to what is meant by the signs. We would argue that this demonstrates a lack of understanding of how linguistic reference functions and what Peirce's chain of meaning entails.

Another (in this case positive) example of applying semiotics to teaching is Hoffmann (2003) who discusses Peirce's solution to another learning dilemma or paradox. Plato observed that a priori inquiry is impossible because a learner must already have the structures before learning and, in general, cognitive gain is impossible. According to Hoffmann Aristotle's solution is to acquire knowledge by induction but that contradicts modern observations about the non-linearity of learning processes. Meyer & Land (2003) use the notion of "threshold concepts" for concepts that are difficult to learn and may involve a complete reorganisation of prior ideas. Thus learning is not inductive and non-linear. According to Hoffmann, Peirce's solution is the use of abduction for forming new ideas and of diagrammatic reasoning for observation and generalisation.

[2] The following website provides an overview of and pointers to relevant research: http://conceptualstructures.org

Hoffmann sees diagrammatic reasoning as an interplay between a-priori and inductive reasoning.

3 Conclusion

This paper argues that Peirce's pragmatism would provide a better foundation for educational research than the currently prevailing constructivism. This is because pragmatism supports the advantages of a constructivist view of learning with a slightly more realist position. While educational developers tend to be pedagogically trained (and thus constructivists), university science teachers tend to exhibit more idealist or realist view which creates a communication imbalance between educational developers and university teachers which would not be the case for pragmatism. The dominance of constructivism remains puzzling. Maybe it is popular because it replaced behaviourism (which did not provide successful methods for higher education). Maybe a less-pluralistic position is more appealing. Maybe constructivism itself is a threshold concept which according to Meyer & Land (2003) would be difficult to unlearn. It is not the aim of this paper to provide any in-depth discussion of philosophical issues but to advocate more widespread publication of pragmatist-based educational research.

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