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Cooperative Didactic Engineering

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Keywords
Design-based research · Methodology · Epistemology · Teaching practice · Didactical engineering

Definition

The Joint Action Theory in Didactics (Sensevy 2019) aims at theorizing a specific process of design-based research (Cobb et al. 2003) and design-based implementation research (Fishman et al. 2013), called *cooperative engineering* (Sensevy et al. 2013; Joffredo-Le Brun et al. 2018), in order to contribute to the elaboration of new forms of schooling. Cooperative engineering (CE) refers to a methodological process in which a collective of teachers and researchers engage in a joint action to codesign, implement, and re-implement a teaching sequence on a particular topic. Each stage of the process is based on an analysis and evaluation of the previous stage, and thus a crucial aspect in the building of a cooperative engineering is its iterative structure. In this respect, it is similar to the lesson studies approach (e.g., Elliott 2012). Another fundamental aspect of this methodological process, similar to a characteristic of educational action research (e.g., Kemmis 2009), is the participation of teachers in the conception of the cooperative engineering process. CE also shares some of the traits of collaborative research (e.g., Bednarz 2009), in particular its focus on the way teachers and researchers can work together. The characteristic features of CE broadly situate it within the learning science paradigm (e.g., Koschmann 2011).

Origin

Cooperative engineering includes "the controlled design and experimentation of teaching sequences and adopting an internal mode of validation based on the comparison between the a priori and a posteriori analyses of these" (Artigue 2018). The origin of this aspect of CE can be traced back to didactical engineering (Brousseau 1997; Artigue 2015, 2018; Barquero and Bosch 2015).

In keeping with other recent developments in educational research, CE takes into account the shift of interest toward teachers' "representations and practices" and "the current evolution of vision of relationships between researchers and teachers" (Artigue 2018); this has led to a redefinition of its modes of validation as we shall see.

S. Lerman (ed.), *Encyclopedia of Mathematics Education*,
https://doi.org/10.1007/978-3-319-77487-9_100037-1

CE's Background Assumptions

First and foremost, CE is based on a challenge to fundamental Western dualisms, including those between theory and practice and ends and means (Dewey 1920). As Dewey argued, such dualisms are social and inherited from political structures of domination. One of the main ends of CE, therefore, is to dilute such dualisms in a practical manner.

Another background assumption of CE is the conviction that practice is dense with problems that science has not yet even begun to tackle. Scientific knowledge of practice is lacunary, and contrary to the view that science holds answers to most problems of practice, CE adopts a stance in which practice situations have to be carefully described and studied before any attempt is made to solve them. Collectively describing and studying practice situations is the first step in the problematization process. In CE, this conception entails priority being given to a bottom-up collective inquiry, aimed at building specific theories of action (Cobb and Jackson 2011) and elements of a principled practical knowledge (Bereiter 2014).

Principles

CE unfolds through a system of ideas that can be seen as Deweyan principles: "Principles are methods of inquiry and forecast which require verification by events" (Dewey 1922, p. 239).

A principle of targeted symmetry. Teachers and researchers are both practitioners but practitioners of a different kind. The idea is that in order to improve an educational process, teachers and researchers are viewed a priori as equally able to propose adequate manners of acting or relevant ways of conceptualizing practice in the elaborated design. Teachers and researcher participate in what is called an *epistemic cooperative relationship*, which postulates striving for an epistemic symmetry in the engineering dialogue.

The necessity of acknowledging differences. Cooperative Engineering requires that every agent be responsible for proposing to the collective her first-hand point of view so as to contribute what she "sees" and what she "knows" from her position. There is a fundamental link between research based on this postulate of symmetry and this acknowledging of differences. The first-hand point of view, *which every participant is able to make explicit*, concretizes differences stemming from each person's experience. Such differences are not founded on the status of someone who knows something versus someone who does not. Rather, they are the result of different experiences in/of the social world relating to the common engineering practice.

The necessity of building a common reasoning about ends and means, and thus the potentiality to play both as a collective and as an individual in the game of giving and asking for reasons (Brandom 2001). In such a game, each participant becomes able to give the rationale of the elaborated structures and is therefore able to understand and build a first-hand relationship with this design rationale, whether it be "practical" or "theoretical," thereby going beyond any epistemic division of labor. By building a common repertoire of described and analyzed practices, participants make themselves capable of designing ends-in-views (Dewey 1922), which emerge from practical accomplishments in the designing process.

The Engineer Stance. Cooperative engineering may foster a kind of *local, practical indistinguishability between teachers and researchers*. At some moments of practice, both of them share an engineer stance, which includes theoretical and concrete ways of responding to a problem of teaching practice. This principle has to be understood as being in relation to the "The necessity of acknowledging differences principle." Speaking of a "local, practical indistinguishability" between the teacher and the researcher does not mean that they fuse together within an unlikely fuzzy stance. It does not erase the differences between the two professions but rather temporally and locally reunites them together under an *engineer stance*. This stance brings all the members of the CE together in a shared epistemic responsibility.

Cooperate to produce a work. In many forms of "collaborative research," teachers and researchers do not work together on a common concrete object, i.e., the designing of a teaching

sequence. In CE, teachers and researchers have to cooperate in order to produce a common work – an *opera* to use the Latin word for "work" or "labor." This common work lies both in the representational structure of the teaching sequence and in the concrete unfolding of the teaching–learning process itself.

This means that in a CE research project, it is the "concrete object," the teaching sequence itself, which is the *touchstone* of the research process. This "concrete object" is enacted in a practical accomplishment, which is depicted in a hypermedia system, as we will see. Such a hypermedia system is a fundamental means of regulation in that it provides evidence through a warranted assertibility process (Dewey 1938).

Cooperate to produce knowledge. Participating in a CE means participating in a knowledge work in a twofold way. Firstly, as in Didactic Engineering, emphasis is put on the piece of knowledge to be taught, which is jointly studied by the members of the CE. Studying a piece of knowledge means building a connoisseur's relationship with this knowledge. It is a long, collective process which precedes teaching. Secondly, the whole cooperative process of designing a teaching sequence can be seen as a production of knowledge in the form of the teaching sequence; this includes the various descriptions, depictions, comments, and analyses that enable it to be understood and mastered.

CE as a Form of Both Anthropological and Engineering Research

The goals of designing teaching sequences and developing theories of teaching and learning are intertwined in CE. Thus, CE is first and foremost fundamental research within an anthropological approach (Chevallard and Sensevy 2014), whose object is the "Didactic Human Fact" (Cloud 2015), i.e., human being learning and human being teaching. But this human fact is always becoming, always virtually other than it is, and as it is constantly in a state of development, never final; it necessitates being transformed to be understood, as in natural science, and the whole process requires transformation for understanding and understanding for transformation.

In this respect, cooperative engineering may contribute to the building of a new research paradigm that is both anthropological and design-based: anthropological in that it aims to elaborate a theory of practice and design-based in that it aims to build better educational designs.

CE: An Epistemology of Paradigmatic Analogy, Toward the Ascent from the Abstract to the Concrete

Sciences of culture are sciences of contexts (Passeron 2013). This means that assertions produced within the sciences of culture have to systematically be referred to the contexts they denote. A good manner in which to build such a frame of reference consists of instituting some contexts as exemplars (Kuhn 1974). We may hypothesize that a given example of practice has to be considered first as an "emblematic example" within a particular research endeavor; this then needs to further pertain to the common knowledge of a research community to become an exemplar in this research community. Such a conception radically inverses standard interpretations of the relationship between the concrete and the abstract in which the abstract is conceived of as the common area shared by some concrete elements. It is based on a Marxian dialectical vision of these relationships, in the sense that scientific activity is seen to render possible the *ascent from the abstract to the concrete* (Engeström et al. 2012; Ilyenkov 1982; Marx 2012; Davydov 1990). According to this epistemology, CE can be seen as a deliberate attempt to fundamentally give priority to the concrete of practice over the abstract ideas that may describe it.

Thus, when in the process of building designs, cooperative engineers institute certain aspects of practice as emblematic examples; this enables them to both illustrate and to understand some crucial dimensions of the teaching–learning process. CE thus puts at the forefront a documenting process, in which emblematic examples are given

to be seen and understood. This is the role of PTHAS.

A Method of Documenting Practice and Research on Practice: The PTHAS

In this way, emblematic examples can be structured and designed in hypermedia systems, picture–text–audio hybrid systems (PTAHS), cf. Sensevy et al. 2018. In such systems, films of practice, as well as various comments on and analysis of this practice, play an essential role (Sensevy 2011; Tiberghien and Sensevy 2012) in documenting its main features. Thus, the epistemology of paradigmatic analogy that we sketched above is also "an epistemology of methodology," in which the progress of knowledge relies on the building, studying, and refining of emblematic examples of practice that serve as frames of reference in the scientific inquiry.

While using PTAHS, a CE team focuses this inquiry on how practice works, in order to answer questions about how a given teaching sequence can be managed and achieved successfully. It is possible to consult an example of a PTHAS[1] elaborated within the ACE (**A**rithmetics and **C**omprehension at **E**lementary School) program (Sensevy et al. 2013; Joffredo-le Brun et al. 2018; Fischer et al. 2018). This program, which aimed at providing a curriculum for the first and second grades in mathematics, is currently based on the development of PTAHS with the twofold goal of enhancing the relevance of the research work as well as reinforcing the concreteness of the dissemination process.

Cross-References

- ▶ Cultural Anthropological Approaches in Mathematics Education
- ▶ Didactic Contract in Mathematics Education
- ▶ Didactic Engineering in Mathematics Education
- ▶ Didactic Situations in Mathematics Education
- ▶ Didactic Transposition in Mathematics Education
- ▶ Didactical Phenomenology (Freudenthal)
- ▶ Joint Action Theory in Didactics

[1] http://pukao.espe-bretagne.fr/public/tjnb/shtis_ace/reseau_ol_explo.html

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