Situating Constructionism

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> Upshot • Constructionism is an epistemology, a theory of design and a theory of learning. It addresses constructivist learning in individual and social environments where bricolage with digital expressive media plays an important role. This editorial situates constructionism within constructivist discourse, and discusses the potential for constructionism to play an identifiable and important role in a wider educational discourse and theory networking. In this framework, it provides a short synthetic review of the eight papers addressing constructionism from a diversity of perspectives.

This special issue was inspired by the discourse and productions of the "Constructionism 2014" conference in Vienna, "Constructionism and Creativity." The conference was the third in a row, after Paris in 2010 and Athens in 2012. It originated from a long-standing conference that had run for 30 years, "Eurologo," after intense reflections. These lead to its restructuring to focus on the essence of understanding and designing for educational practices involving the construction of meanings individually and in social settings where bricolage with expressive digital media has a primary role.

Constructionism was the term coined by Seymour Papert (Papert 1987; Harel & Papert 1991) to draw our attention to the meanings learners generate while they engage in bricolage with expressive digital media (Papert 1972, 1980). Implicitly, constructionists have perceived meaning making through the process of tinkering with digital media as a creative activity (Kafai, Peppler & Chapman 2010; Resnick, Berg & Eisenberg 2000). However, little explicit attention has been given to the kinds of creativity inherent in constructionist activity as such (Liljedahl & Sriraman 2006). Researchers on creativity in learning have recently moved on from perceiving it as a gift (Mann 2006) to adopting a wider view that meaning making is creative in itself (Sternberg & Lubart 2000).

Papert challenged contemporary readings of Piaget that to study learning was mainly about describing learners' shortcomings in understanding taken-as-ontological meanings at different stages in life. Instead, he pointed to Piaget's constructivist ideas, focusing specifically on the potential for the uses of digital media in pedagogy and in domain knowledge, albeit for mathematical learning processes. Constructionism endorses the principles of radical constructivism, i.e.,

> "1. Knowledge is not passively received either through the senses or by way of communication, but it is actively built up by the cognizing subject. 2. The function of cognition is adaptive and serves the subject's organization of the experiential world, not the discovery of an objective ontological reality." (Glasersfeld 1988: 83; quoted in Riegler & Steffe 2014)

However, it organically includes the uses of digital media as one of the means of externalizing meaning by expressing thoughts and meaning along with language, gesture and other representational registers (Morgan & Kynigos 2014). Meaning is thus communicated amongst individuals and made more visible to researchers by means of changes made to the artifacts in question (Weir 1986).

Papert claimed that digital artifacts could play the role of expressive media, augmenting opportunities for meaning making in pedagogically engineered learning environments. In that sense, constructionism began drawing attention as an *epistemology of mathematical learning* and as a *design theory* and perhaps less attention to a third aspect, that of a *theory of learning* (Kynigos 2015). The two former aspects were confrontational yet stimulating and visionary in their time.

With respect to epistemology, constructionism had extended to young children Imre Lakatos's provocative portrayal of the process of mathematicians doing mathematics as the production of potential axioms and proofs in order to engage in the process of refuting them (Lakatos 1976). Lakatos's claim was that mathematicians express mathematical ideas in order for them to be refuted by themselves or by others. The essence of the mathematical process is a reciprocity between proof and refutation. Perceiving mathematics as the set of end products of this process does not give an accurate idea of what it means to engage in mathematical activity. Papert's suggestion was that students could use the computer to construct models of figures by means of programming (Papert 1972). He reified his theoretical claims by developing and using the Logo programming language and in particular "Turtle Geometry," where programs create figural models made by changes to the "turtle's" state (the turtle was a model of a vector with position, heading and zero length, see Abelson & diSessa 1981). These models, both their figural and formal descriptions, were seen as externalized expressions of ideas and thoughts. The act of constructing a model constituted making a sequence of ideas public for discussion and change. The models or artifacts thus had the status of being malleable, of being questionable or improvable propositions for an on-going discussion around subsequent changes to the artifacts. They had the same role as Lakatos's mathematical propositions expressed by mathematicians with formal notation in order for a refutation-and-proof dialectic process to start. Only here, the representations, albeit mathematical, were connected and designed for youngsters to use and give meaning to; the expressive tool used provided feedback, and interactivity and the constructions were extensible (Papert 1980). The same applied with respect to programming, where Papert made the

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same analogy between the activity of professional programmers working with the LISP language (Sinclair & Moon 1991) and young learners.

With respect to design, Papert was also the first to suggest that *designing* environments for rich meaning making was possible. He coined the notion of a "microworld" to describe a digital artifact designed to invite engagement in activity, ownership of ideas and learning style and exposure – i.e., expressing one's own ideas to others – for exploration, negotiation and communication (Healy & Kynigos 2010). Microworlds are self-contained worlds where students can "learn to transfer habits of exploration from their personal lives to the formal domain of scientific construction" (Papert 1980: 177). Later elaborations of the term referred to tasks for the learner that invited meaning making, to the embedding of powerful ideas in a microworld (Sarama & Clements 2002) and to the pedagogical technique of designing fallible artifacts, termed "half-baked" microworlds (Kynigos 2007). "Half-baked" microworlds are intentionally incomplete or buggy models given to learners to try out, to open up, to make changes to and to re-mix. They are like refutable mathematical propositions, artifacts to generate meaning-making environments with considerable focus and structure. The art in designing a half-baked microworld is thus to think of what mathematics *to take away* from a generalized model. Designing these kinds of artifacts was also important in changing the perception that concrete thinking was a "lesser" kind of cognitive process than abstract thinking by pointing out that proper and rich exposure to the former was pivotal in ever hoping to reach the latter (Turkle & Papert 1991). Work on design has also pointed to the need to reconsider the ways in which domain knowledge is structured in education with a view to shape structures so that they become more amenable to meaning making by changing representational registers, engineering situations where meanings become useful and usable and inventing affordances for bricolage and construction of models (Wilensky & Papert 2010).

Some work has been done to develop scientific validation of learning processes in constructionist environments. One such tool, used to understand meaning-making processes while learners work with a microworld, distinguishes between discriminating, using, generalizing and synthesizing mathematical ideas (Hoyles & Noss 1987). Another points to engaging in abstractions within situations where students use particular representations and affordances to generate particular digital constructs (Noss & Hoyles 1996). However, not unlike discourse amongst constructivist theorists (Riegler & Steffe 2014), constructionist theory does not only address the individual (Resnick 1996). Yasmin Kafai and Quinn Burke (2014) elaborated on the process of constructionist activity in interactionist and more broadly social settings. They studied meaning making during students' exchange, re-mix and publicizing of their artifacts and their engagement in discussion, discourse, dialogue and negotiations over the process of bricolage.

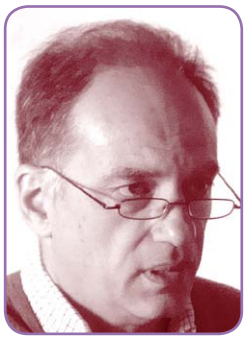
This special issue reflects the discussions on constructionism as epistemology and as a usefully developing theoretical tool for designing for and understanding – as **Richard Noss** and **Jim Clayson** put it in their opening article – "behavior and expression" with digital artifacts. The authors of the opening article discuss an agenda for constructionism based on the need to emphasize and enhance its scientific validity as a theoretical tool for understanding and designing for learning with expressive digital media from a constructivist perspective. Their agenda points to pivotal aspects of learning with digital media, such as modeling and learner accessibility to the modeling process, representing knowledge in a learnable language and making it possible for learners to decide how deep to dig into ideas embedded into the tools, their behaviors and functions. Furthermore, they stress the importance of tapping into youth culture, democratizing design by recognizing its value for learning and better understanding the ways in which digital artifacts are mediated within communities through a reciprocal shaping process.

The target articles in the issue not only reflect the various aspects of Noss & Clayson's agenda but raise broader issues involving particular ways in which constructionism addresses issues pertinent to the constructivist discourse.

With respect to the agenda, **Nicole Panorkou & Alan Maloney** and **Eirini Geraniou & Manolis Mavrikis** address domain knowledge and the question of what is learned by considering particular concepts during geometrical transformations and algebraic abstraction. The former authors discuss interesting ways in which 4th graders reasoned about translations and rotations with a specially designed tool involving figural representations and transformation animations. The latter studied 11–14-year-olds' work with a tool for representing algebraic generalizations of tile pattern descriptions, and studied the ways in which the students were supported to express algebraic meaning while transferring from digital to pencil and paper notation.

But there is also a need to understand constructionist learning processes better, as exemplified in the article on the process of deconstructionism by **Pavel Boychev,** and on the process of pattern identification to understand early algebraic concepts through modeling by **Chrystalla Papademitri-Kachrimani**. Boychev worked with university undergraduates and secondary students learning to program and particularly focused on the creativity and the meanings generated during the process of deconstructing digital models, claiming that deconstruction has been given little attention although it is a mirror activity to construction. Papademtri-Kachrimani shows how researchers, teachers and 5-year-old children creatively learn how to think about and connect patterns to numerical relations with a modeling kit made up of tangible rings.

Maria Daskolia, Chronis Kynigos & Katerina Makri discuss how to elaborate and re-consider the role of "powerful ideas" embedded in digital artifacts and the ways in which they can be utilized in broader educational contexts where the target is a loosely-defined complex system such as the issue of city sustainability, rather than a conceptually cohesive microworld. Their article raises questions such as: Does constructionist learning only need to be about working with models? Or only about scientific / mathematical / computational models? Can a piece of art, a piece of text, a human situation game usefully play the role of a constructionist artifact? **Chronis Kynigos** discusses how to think of the role of emerging new kinds of



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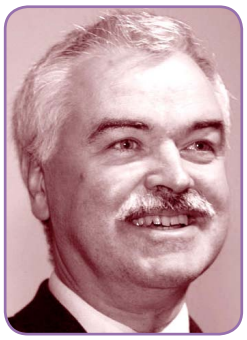

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artifacts, such as constructionist e-books, as expressive media and of the processes by which they are mediated in communities. **Edith Ackermann** raises the issue of going beyond the cognitive and social aspects of meaning generation by seriously considering the affective, and in particular, humor. She takes three examples, the craftsman, the poet and the trickster, to show some of the oblique ways of knowing, such as "possibilizing," that bring insight and creativity.

The importance of developing methods and tools to understand the social and systemic contexts within which constructionist activity may take place is discussed, for instance, by **Karen Brennan** involving classroom practices and by **Kynigos** involving design communities. Brennan discusses ways in which teachers can be supported to support constructionist learning in the classroom in turn by placing teachers in the context of designer communities that discuss the artifacts they create and their agendas for how to use them with their students. The importance of the endeavor to address the broader education community by joining in wider discourses permeates some of the papers, see, e.g., **Kynigos**, **Daskolia et al.** and **Ackermann**. Respectively, they discuss constructionism in designing and "reading" e-books, constructionism in broader challenges to meet complex loosely-defined tasks where powerful ideas only play secondary roles and meaning making is a process not only involving the cognitive and the social but also affect and humor.

This issue thus attempts to situate constructionism within the constructivist discourse and then beyond that within the wider educational discourse to elaborate on its identity, connectivity and coherence, joining in the process of networking amongst theories (Prediger, Bikner-Ahsbahs & Arzarello 2008; Kynigos 2012). It also attempts to draw attention to the role of digital artifacts in expression, representation and meaning making individually and in social contexts. Much like constructionist theory so far, creativity is implicitly inherent in papers in the issue, especially those more narrowly connected to domain knowledge, such as those of **Panorkou & Maloney**, **Papademitri-Kachrimani** and **Geraniou & Mavrikis**. Some others, however, bring the issue of creativity up front, showing how social creativity in learners (**Daskolia et al.**, **Ackermann**, **Boychev**) and resource designers and teachers (**Kynigos**, **Brennan**) can be seen as an explicit aspect of meaning making in social constructionist settings.

There is more to be done on all three aspects of constructionism, i.e., epistemology, design and learning theory. The education world is in flux: knowledge domains, their structure in educational settings and the fragmented nature in which they are placed in curricula are all being questioned in the emergent knowledge society. Papert's visionary and provocative challenge to question how we view learning and knowledge from an epistemological perspective is even more relevant some 40 years later. The democratization and recognition of designing artifacts, activities and resources as a natural aspect of professional activity for teachers and others in the education field is drawing attention. The need to develop theoretical tools for understanding the design process from the professional's point of view and its potential relations to affording constructionist learning styles is becoming clearer. Finally, Noss and Clayson cite Andrea diSessa and Paul Cobb to stress the need for the production of more fine-gained systematic theory for constructionist learning, i.e., to "develop theoretical constructs that empower us to see order, pattern and regularity in respective educational settings" (diSessa & Cobb 2004: 84).

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