tioned in §58? (Q2) I would argue that, from a computer science perspective, these programs are just part of the products, which – standing alone – do not say much about the genuine understanding of the learners and even more so do not reveal anything about the learning process. Thus, my final question to the authors would be: What role should these products play in the evaluation of students’ performance – are they just by-products of learning or should we grade our students based on the performance, functionality, look, etc., of their interactive objects? (Q3)

As a final thought I would like to add that I see a high value for computer science (and general) education in the implementation of projects in which pupils, for example, aim to build and network a Smart City from LEGO bricks or to equip the school with interactive Halloween decorations, although this results in concrete products. It is not a question of no longer developing products in educational settings, but of supporting pupils on their way to their final products in such a way that they become aware of the learning process, externalize knowledge and concepts and “[…] reach a new level of scientifically based knowledge that is a product of a growing learning spiral,” as Blikstein and Valente put it ($16$).

References


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Applying the Practices of Makerspace in Other Educational Settings

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>Abstract • Makerspaces, if enriched with mediation and reflection as well as social interaction with experienced learners, can be used as a model for designing learning environments for researchers’ education at all stages of their development.

Introduction

In primary and secondary education, the ideas of Seymour Papert’s constructionism became widely accepted and disseminated by the “maker movement” for the reasons well summarized in §10f of José Valente and Paulo Blikstein’s target article. Still, using this learning methodology to build conditions for developing research abilities and problem-solving minds at the level of PhD studies seems unusual. Yet the relation between making, learning and mediation (facilitation), problematized by Valente and Blikstein, as well as their discussion of the role of digital representation and teacher (or expert partner) in the learning process, is relevant for a wide variety of educational environments, including postgraduate education.

A research environment (either a laboratory or an archive of artifacts) is very similar to a makerspace: the researcher is a learner who interacts with objects, uses digital information and communication technologies and digital fabrication technologies, and is not necessarily aware of all the concepts and scientific knowledge that can be employed to construct new knowledge, especially in interdisciplinary or innovative investigation. If we re-interpret research practice as makers’ activity from the perspective of constructionism, then the concept of using digital technologies as a “window into the mind” (as suggested in §16) for knowledge representation in a “growing learning spiral” gives us a new perspective on how to design learning environ-
mements for producing innovative knowledge both as a part of training and in research. Procedures for testing hypotheses and initial assumptions with representation in digital modelling are now gaining more and more popularity both in the natural and the social sciences.

Considering the growing significance of transferrable skills and developing personal effectiveness in postgraduate education, the link between social development and character building in makerspaces (emphasized in §19) gives even more arguments for using this type of educational space in higher-education institutions. Empowering agency in learning is also important from a perspective of developing entrepreneurship skills and the ability of self-evaluation for lifelong learning.

**Mediation and Reflection**

The obvious benefits of “hands-on” learning often create the illusion of simplicity in the implementation of constructionism, therefore Valente and Blikstein reconsidered cognitive concepts of Jean Piaget and Lev Vygotsky to clarify the aspects of agency in knowledge transformation. This is a very important point for consideration in the context of the development of scientific concepts in research. In §26 the authors insist that “mediation” is necessary for learners (researchers) to be able to achieve development (as opposed to going through the “learning process,” according to Vygotsky as cited). This brings a new horizon for envisioning the role of supervisors and experienced researchers as constructors of the “zone of proximal development” for the effective functioning of research groups.

The authors describe the process of learning in makerspaces as starting from the action phase (Figure 5), then they claim that there is a need for reflection, comprehension and conceptualization (often omitted in many makerspaces) with the assistance of the teacher. “Action” is similar to the experimental or modelling phase in research, but in the postgraduate educational environment, the reflection could be mediated not only by the conceptual thinking of a more experienced researcher, but also by the assistance of the peer group, i.e., by structured “peer-led activities.”

The opposition between “product construction” and the “construction of knowledge,” well described in §59, in application to research will illuminate the need for more interaction between researchers and technology to represent stages of reflection on the way to new knowledge. The practice of reflective communications following the creation of the designed research object with either a senior researcher or the peer group, provide the structure for a more effective evaluation of the preliminary results of research and knowledge conceptualization.

Thus, in the discussion about structured PhD education as opposed to the individual research-based model, one could refer to makerspaces experience and argue that “just doing experiments” would not be enough for reaching the stage of innovative research. Here, we can also use Piaget’s distinction between “success” in performing desired activities and “understanding” to support the need for a reflective (learning) phase in any research practice.

One might object that we could not apply the concepts Piaget and Vygotsky initially developed for explaining the process of cognition in childhood and adolescence to research. However, both a child and a researcher at the beginning of experimenting stay in the same zone of pre-knowledge and go through similar stages of knowledge construction and both need social interaction to get to the level of conceptualization.

**Conclusion**

Many of the valuable observations discussed in the target article, related to makerspaces, could be reapplied to the research environment since both educational settings aim at creative and active creation of knowledge instead of repetition or duplication. The digital revolution made learning a part of the research process not only within structured doctoral education, but also in the lifelong professional development of a researcher.

The authors encourage educators to reflect on the makerspace activities to support the initial objective of constructionism of developing learners’ problem-solving capacity. A makerspace learning environment empowered with reflective practice should be very effective at establishing a risk-taking mindset, though the potential of Papert’s constructionism in lifelong learning needs further investigation.

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