Constructionist Approaches for Computational Thinking in Math and Science classrooms

Uri Wilensky# & David Weintrop*
uri@northwestern.edu, dweintrop@uchicago.edu
Center for Connected Learning and Computer-based Modeling
Learning Sciences & Computer Science, Northwestern University
* UChicago STEM Education, University of Chicago

Objectives

Modern science and mathematics are increasingly computational endeavors. To reflect this shifting reality, national standards efforts like NGSS and CCSS either include specific computational practices (such as the computational thinking practice in NGSS) or concepts and practices particularly well suited for computational learning contexts (like model with mathematics in CCSS). In this presentation, we argue that constructionist learning, with its emphasis on the creation and sharing of constructed artifacts (physical or virtual), productive and innovative uses of computational technologies, and the inclusion of opportunities for personally-meaningful learning, is particularly well suited to achieve the desired goals of these standards efforts. Further, we argue that the idea of computational thinking and the use of computation as a context in which to situate meaningful mathematical and scientific learning is a fundamentally constructionist idea, with its roots dating back to the earliest constructionist learning tools.

Theoretical Framework

This presentation is firmly rooted in the constructionist literature and draws on over 40 years of work showing constructionist theory and design to be an effective approach for engaging learners in the powerful ideas of mathematics and science. This includes early work with the Logo environment on the development of mathematical thinking (Feurzeig, Papert, Bloom, Grant, & Solomon, 1970; Papert, 1972, 1980; Papert, Watt, diSessa, & Weir, 1979), and more recent projects looking at computational modeling as a way to deepen learning of scientific ideas (Blikstein & Wilensky, 2009; Hmelo et al, 2015; Klopfer, Yoon & Um, 2005; Sengupta & Wilensky, 2009; Wilensky, 2001; Wilensky & Reisman, 2006; Wilkerson-Jerde, Wagh, & Wilensky, 2015). The second literature this presentation draws from is work showing that mathematics and scientific content can provide meaningful contexts to engage learners with powerful computational thinking ideas (Guzdial, 1994; Orton et al., 2016; Weintrop et al., 2016; Wilensky, Brady, & Horn, 2014; Wilensky & Rand, 2015).

Methods and Data

This presentation will employ data collected over the last three years from two research projects designed to bring computational thinking into public high school classrooms. The first project pursued the goal of embedding computational thinking into existing high school mathematics and science classrooms (Orton et al., 2016) through the design of computational thinking enhanced STEM units. The second project designed a yearlong computational thinking course with the goal of broadening participation in computing by providing a diverse set of entry points into the field, including numerous computational modeling and programming units (Brady et al., 2016).

Results

We present findings from these two projects showing how constructionist learning can productively engage learners in meaningful mathematics and science learning. We will provide evidence of learners improving their computational thinking skills after working through the constructionist computational thinking in math and science units we designed. Additionally, given the focus that NGSS and CCSS place on practices, we will provide vignettes of learners engaging in the productive scientific and learning practices of problem formation, solution development, and debugging while working on content from across the STEM spectrum. An emphasis will be placed on practices associated with the design, implementation, and evaluation of computer-based models of scientific and mathematical phenomena, a constructionist activity that blends STEM content and computational thinking.

Scholarly significance

There is growing acknowledgement of the importance of learners engaging in authentic mathematical and scientific practices. It is becoming increasingly important to design learning activities that support these practices. At the same time, computation is playing a growing role in scientific and mathematical endeavors, making, authentic practice an increasingly computational undertaking. This presentation provides evidence that constructionist learning is well suited to foster meaningful mathematical and scientific learning in a way that develops authentic practices. By providing examples of constructionist learning in mathematics and scientific contexts, we show the power of this approach and offer potential future directions for the creation of engaging and effective constructionist learning activities for mathematics and science classrooms.

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