Chapter 15
Elementary Students as Digital Makers:
Improving STEM+C Teaching and Learning With Digital Making

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ABSTRACT

The solution to the nation's shortage in STEM workers begins in elementary schools. However, elementary teachers are not well prepared to teach STEM, and they lack the knowledge and competency to inspire students early on in the fields of science, technology, engineering, mathematics, and computational thinking (STEM+C). Consequently, elementary students' wellbeing in STEM+C learning is negatively affected. Preparing elementary teachers for teaching STEM+C with digital making is suggested in this chapter as a means to improve elementary teachers' STEM+C teaching competency and to improve elementary students' wellbeing in STEM+C learning. This chapter also proposes and discusses related approach, framework, and pedagogy to illustrate how elementary teachers can teach STEM+C effectively by engaging elementary students as digital makers. Suggestions for future research are also discussed in this chapter.

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INTRODUCTION

Continued U.S. competitiveness in an increasingly global economic environment relies heavily on an adequate supply of qualified STEM (science, technology, engineering, and mathematics) workforce (National Research Council, 2011; National Science Board, 2015; President's Council of Advisors on Science and Technology, 2010; U.S. Department of Labor, 2007). According to the U.S. Bureau of Labor Statistics, the future of the economy and the jobs of tomorrow are in STEM (U.S. Bureau of Labor Statistics, 2014). STEM related jobs are projected to grow more than 9 million between 2012 and 2020 (U.S. Bureau of Labor Statistics, 2014) with 8.6 million STEM jobs already in May 2015 (U.S. Bureau of Labor Statistics, 2017). Unfortunately, going alongside with the high and increasing demand for STEM workers is the shrinking STEM workforce pipeline: U.S. students are discouraged from entering the STEM pipeline due to inadequate preparation in math and science and lack of interest in STEM disciplines.

What is the solution to the shortage of STEM workers? The solution does not begin with students in college; it begins in elementary schools. Research has shown that, because of the isolated and disjointed fashion that mathematics and science are taught in schools, students begin to lose interest in STEM near the middle school years (Finson & Enochs, 1987; Barmby, Kind, & Jones, 2008; Bennett & Hogarth, 2009). There is an urgent need for well-trained elementary teachers who are prepared to inspire students early on in the science, technology, engineering, and math fields when students are still open and curious about the world around them and stereotypes about gender are not so strongly formed yet. Students' foundational knowledge of and interest in STEM are formed in their elementary education. Paradoxically, elementary teachers have constrained background knowledge, confidence, and efficacy for teaching STEM, which consequently hampers students' STEM learning and motivation (Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013).

Elementary teachers' unpreparedness for STEM education results naturally from the fact that elementary education is not traditionally an area of focus for STEM teaching and learning. Many teacher preparation programs do not require rigorous coursework in the science, technology, engineering, and mathematics subjects for candidates pursuing elementary grade certification. According to National Council on Teacher Quality (2014), of the 907 undergraduate and graduate elementary programs across the nation, nearly half (47 percent) fail to ensure that teacher candidates are capable STEM instructors: these programs' requirements for candidates include little or no elementary math coursework and the programs also do not require that candidates take a single basic science course (with most giving candidates free rein to choose from a long list of narrowly focused or irrelevant electives).

Stepping out of teacher preparation programs into real classrooms does not put elementary teachers in a better situation of getting prepared for teaching STEM. Elementary teachers lack in-service STEM professional development opportunities. Although recent years have witnessed more STEM professional development opportunities made available to elementary teachers through STEM projects funded by federal or local educational agencies, these efforts are limited in their impact of improving elementary STEM education because: 1) not competency-building in nature, such efforts are mostly top-down typically involving training elementary teachers to implement some new learning modules or curriculum on topics in a STEM subject area; 2) these learning modules or curriculum, mostly as an add-on to elementary teachers' teaching load, are unlikely to continue to find their way into elementary teachers' tight daily schedule beyond the funded project period; and (3) such efforts are mostly narrow focused failing to provide elementary teachers with a clear and broad picture of the fundamental STEM skills