Chapter 15
Makerspaces as Learning Environments to Support Computational Thinking

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ABSTRACT

Makerspaces are technology-rich learning environments that can uniquely support children's development. In education communities, makerspaces have become sites to take up explorations of personally-motived problem solving, and have been tied to 21st century learning outcomes of perseverance, creativity, persistence, and computational thinking. Elsewhere in this book, Bers described computational thinking as the set of skills and cognitive processes required to give instructions for a specific task in such a way that a computer could carry it out. But Bers also argued that the purpose of computational thinking is to cultivate a fluency with technological tools as a medium of expression, not an end in itself. Computational making is part of this expression. This chapter explores the ways in which tools, facilitation, and the physical environment can support children's engagement with powerful ideas of computational thinking through making.

INTRODUCTION

Makerspaces have become sites to take up exploration of personally-motived problem solving, and have been tied to 21st century learning outcomes of perseverance, creativity, persistence, and--particularly because of the emphasis on creation with digital tools--computational thinking (e.g. Campbell, Heller, & Goodman, 2018; González-González & Arias, 2019; Iwata, Pitkänen, Laru, & Mäkitalo, 2020). Elsewhere in this book, Bers described computational thinking as the set of skills and cognitive processes required to give instructions for a specific task in such a way that a computer could carry it out. But

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Bers also argued that the purpose of computational thinking is to cultivate a fluency with technological tools as a medium of expression, not an end in itself. Makerspaces provide informal learning spaces in which this can happen through computational making.

While the concept of computational making is nascent, we use the term in this chapter to refer to any creative making or design endeavor in which makers (anyone who creates or tinkers) leverage computational thinking skills (e.g. as outlined by Bers, 2020), to achieve their creative goals. We do not propose that computational making is a learning domain or a standard in itself. In much the same way that picking up and putting down weights isn't the reason one goes to a gym as much as maintaining overall health and wellness, and mastering grammar and syntax isn't the reason to learn a new language as much as self-expression and communication, we argue that making is not necessarily an educational goal itself. Rather, we pose in this chapter that an educational goal of making is to support the maker in developing a suite of psychosocial behaviors and character traits, including (but not limited to): confidence to tackle unstructured problems, competence with a range of physical and digital tools and creative practices, critical thinking skills to evaluate problems and imagine logical solutions, and creativity and agency to determine which problems to address that are personally or communally meaningful. By extension, an educational goal of computational making is to cultivate those same skills and behaviors, but in the context of projects that incorporate digital and technological tools, computational thinking skills, and disciplinary practices from fields such as computer science and engineering. Maker educators are familiar with the phrase, "children should be creators, and not just consumers of their own digital experiences" (Smith, 1982). By providing tools, community, and an environment to enable computational making, a makerspace supports children in creating, rather than consuming.

In the following chapter, we explore research on the educational affordances of makerspaces, with a focus on opportunities for computational thinking and making in the early years. Following this, we describe practice-based examples of computational making inspired by real children and events from our experiences designing and evaluating early childhood makerspaces. We use these examples to illustrate how computational making supports learning in areas such as computational thinking and creative agency. Finally, we share evidence-based principles for designing and facilitating a makerspace to support computational making, and conclude with a reflection about the impact of computational making on children's ability to create their own artifacts and ideas.

BACKGROUND

What is a Makerspace?

Soldering irons, 3D Printers, and robots are some examples of tools that people commonly feel are too complicated for most education settings, especially early childhood ones. In the early 2000s, the maker movement, branded by Dale Dougherty's *Make Magazine,* began to rise in popularity with the promise to democratize tools, expertise, and learning models of production (Dougherty, 2012). His conceptualization of makerspaces was widely interpreted to be in the same spirit of public libraries and their promise to democratize knowledge and literacy (Lakind, Willett, & Halverson, 2019). As Dougherty defines them, makerspaces are any places where people get together to *make*. The content of what is made can vary. It is the mindset of the community, the affordances of the available tools, and the intended purpose of the space that defines the unique identity of a makerspace. While the environment, community expertise,

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