

## Chapter 17

# Impediments to Digital Fabrication in Education: A Study of Teachers' Role in Digital Fabrication

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### ABSTRACT

*Digital fabrication technologies are increasingly integrated across subjects in primary and secondary education. Focus on the potentials of these technologies has mainly been on the support to STEM oriented learning goals, while emphasis on teachers' roles with the new learning processes of technology and design is largely absent. The paper addresses the experiences and challenges that digital fabrication technology present for teachers in educational environments, and the impediments that are linked to the teachers' roles in design processes of digital fabrication. Based on a research study with eight primary and lower secondary teachers, the findings point to four central impediments for integrating digital fabrication and design into school environments. The findings extend current perceptions of digital technology in education towards exploratory processes of investigation in which the teachers' roles are fundamental.*

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## INTRODUCTION

For the past decade, researchers have been studying the potential for using emerging digital fabrication technologies as a way of actively engaging students in digital production and fabrication (Gershenfeld, 2005; Blikstein, 2008). Their accounts reveal that fabrication technologies such as 3-D printers, laser cutters and electronic building sets are gradually becoming better suited to supporting learning purposes and are increasingly being integrated into educational environments (Blikstein, 2013). Research on the use of these technologies in education has mainly focused on their potential as tools for STEM-oriented learning (in science, technology, engineering and mathematics, STEM). More recently, however, researchers have advocated broadening the scope of digital fabrication technologies in education with a view to additionally including elements of design thinking in education (Katterfeldt et al. 2015; Smith et al, 2015). As summarized by Schelhowe (2013), the use of digital fabrication in education provides children with a sustained understanding of digital technology and supports their ability to design with digital material. At the same time, it also offers researchers a way of accessing reflections on the post-modern society mediated by digital technology. Zeising et al. (2013) emphasize that digital-fabrication processes can build digital literacy in the form of a reflective understanding of digital technology and an understanding of the design process itself, as well as the students' self-efficacy. In this respect, digital fabrication processes not only develop STEM competences as so often emphasized, but they can also develop a more profound understanding of self and society (Schelhowe, 2012). Eisenberg (2013) and others, however, critically argue that digital fabrication technologies do not have the potential for teaching students forms of digital literacy unless we focus more on design processes and less on "push-button exercises" that do not lead to substantial learning outcomes for students. In fact, most of the authors in the field point to the critical concern that both students and teachers have difficulty transgressing the "keychain syndrome": that is, moving beyond producing simple aesthetic objects such as key chains on the laser cutter and into the messy fabrication process.

In line with the extended approach to digital fabrication introduced above, we advocate an enhanced definition of digital fabrication in education. In our view, this approach is not just a matter of learning-oriented activities of design and construction with technologies. Rather, we emphasize a designerly approach to digital fabrication, enabling *a hybrid learning environment that combines digital fabrication, design thinking, and collaborative ideation and innovation aimed at addressing complex societal challenges* (Smith et al., 2015). This definition stresses the entire creative process –from early ideation, sketching, and mockup creation to the initial presentation of a prototype. In this process, digital fabrication becomes a vehicle and resource for addressing both personal and complex societal issues.

In this paper we study eight teachers' experiences of (and reflections on) integrating digital fabrication and design thinking into upper primary and lower secondary education. The study specifically examines the teachers' role when facilitating processes of design and digital fabrication. The empirical outcome of the study – observations, interviews and diaries - was analysed, and four impediments were identified that challenge the potentiality of digital fabrication in education. All four of these impediments relate to the role of the teacher and (curriculum-based) goal-oriented educational practice in the convergence with (experiment-based) exploratory ambitions of digital fabrication and maker culture.

Below we account for our research approach and our experiment with the teachers in processes of digital fabrication in education. We present the findings from the study, focusing mainly on three aspects: (1) the complex design process; (2) managing technologies and materials; and (3) balancing different roles as teachers. Finally, we discuss the impediments to digital fabrication in education, moving beyond

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