Chapter 21
Using Technology to Engage Students with the Standards for Mathematical Practice: The Case of DGS

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ABSTRACT

This chapter discusses how the use of Dynamic Geometry Software (DGS) can be used to support students' engagement with the Standards for Mathematical Practice as outlined in Common Core State Standards for Mathematics (CCSS-M). In particular, the aim of this chapter is to (1) describe what students' strategic use of appropriate tools might entail in a DGS environment, and (2) argue that for students to engage in these practices in a DGS environment, they must construct meaning for and with these tools in the process of instrumental genesis. Illustrative examples are provided from three secondary mathematics classrooms, and the chapter concludes with recommendations for future research and teacher education in this area.

INTRODUCTION

Research on the use of technological tools for mathematics instruction and learning has proliferated over the last twenty years (e.g., Burrill et al., 2002; Heid & Blume, 2008; Kaput, 1992; Zbiek, Heid, Blume, & Dick, 2007), and has demonstrated that the use of technological tools can be effective in supporting students' learning of important mathematical concepts and procedures. Concurrently there has been increasing emphasis on developing students' ability to engage in mathematical thinking and reasoning (e.g., Cuoco, Goldenberg, & Mark, 1996; Hiebert et al., 1997; National Council of Teachers of Mathematics, 2000, 2009; Stein, Smith, Henningsen, & Silver, 2009). The release and adoption of the Common Core State Standards by the majority of U.S. states, and in particular the Standards for Mathematical Practice, has resulted in increased attention on how to engage students in these practices. For the first time in the history of mathematics education in the United States, students' mathematical thinking and behaviors, and not just content, may be specifically assessed on a large scale as part of binding policy.

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However, most research on the use of technology for mathematics instruction and learning has focused on how technological tools support students' learning of content. More research is needed that focuses on how technological tools may be used to support students' mathematical thinking and behaviors, such as those outlined in the Standards for Mathematical Practice. In particular, both researchers and practitioners need a deeper understanding of what using appropriate tools strategically consists of, how teachers can foster this behavior in their students, and how it is related to the other mathematical practices outlined in the Standards.

The purpose of this chapter is to present examples that illustrate:

1. What using appropriate tools strategically may consist of in a classroom learning environment integrating Dynamic Geometry Software (DGS), and
2. The role of instrumental genesis in supporting or hindering students' ability to engage in this practice.

The aim is not to advocate for the use of DGS, or technology in general, as a magic pill for promoting students engagement with the mathematical practices. Indeed, the non-examples described in this chapter are poignant counterexamples of such a notion. Rather, by unpacking the ways in which students use, or fail to use, appropriate tools strategically, the reader may gain insight into what this practice consists of in a DGS environment. In addition, the importance of students having opportunities to construct mathematical meaning for the tools that they use, and the role of this process in supporting students' engagement with this practice when using DGS, is highlighted in these examples.

The Case of Dynamic Geometry Software (DGS)

Dynamic geometry software (DGS) such as Cabri Geometry, Geometer's Sketchpad, and GeoGebra are a specific case of a more general learning context that has been referred to as Dynamic and Interactive Mathematics Learning Environments (DIMLE) (Karadag, Martinovic, & Frieman, 2011). In addition to DGS, these refer to any learning environment in which digital technologies are used to engage students in explorative learning. Dynamic geometry software in particular has become increasingly common in secondary schools, and provides a means of making mathematics instruction more student-centered by having students learn new content through guided exploration rather than lecture and applications. Both the ubiquity of this technology, and the ability to integrate it into classroom instruction for the learning of new content, make it important to understand how this tool can also support students' engagement in mathematical practices.

THEORETICAL BACKGROUND

An intended contribution of this chapter is to connect the practice of *using appropriate tools strategically* to theoretical lenses developed in the mathematics education literature. In particular, the use of DGS to engage students in *transformational reasoning* (Simon, 1996) is proposed as an important element of strategic use of this tool. The notion of *instrumental genesis* (Drijvers & Trouche, 2008; Guin & Trouche, 1999) as a way to describe how learners construct meaning with and for tools, and is used to describe a necessary condition for students to engage in this practice.