

Chapter 20

Dynamic Approach to Teaching Geometry: A Study of Teachers' TPACK Development

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ABSTRACT

Secondary geometry teachers from several urban school districts participated in a two-year professional development focused on integrating dynamic geometry into teaching. The chapter documents the positive impact of the professional development for teachers' Technological Pedagogical Content Knowledge (TPACK) development and their students' achievement in geometry through the use of the dynamic geometry approach. Instruments used to develop and assess teachers' TPACK included a Conjecturing-Proving Test, interviews and observation protocols. Participants' TPACK levels were identified using a TPACK Development Levels Assessment Rubric. Findings show that teachers' TPACK tended to remain within the three middle TPACK levels (accepting, adapting, and exploring). Recommendations and suggestions for future research are offered to those who implement school-based, mixed methods research studies involving technology.

INTRODUCTION

High school geometry is a crucial subject for the 21st century. Dynamic geometry software provides teachers and learners with a valuable tool to construct knowledge and gain insights about geometric reasoning and proof. Research is needed on how to develop both teachers' and students' ability to make effective use of dynamic geometry software in school settings to meet the goals of Common Core State

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Standards Initiative (National Governor's Association Center for Best Practices and Council of Chief State School Officers [NGA & CCSSO], 2010) and other educational standards.

Geometry is an area in need of improvement in mathematics education. U.S. students' geometry achievement is low at all grade levels (Battista, 2007; Senk, 1985). Students entering high school have little knowledge or experience of geometric properties and relationships, often operating at the visual level of geometric thought and experiencing difficulties for tasks more than recognizing different geometric shapes (Fuys, Geddes, & Tischler, 1988; Scally, 1990). In the only states where researchers were easily able to find item analyses (such as Texas and Florida), at least 40% of the students struggled with state test items in topic areas including volume, applications of the Pythagorean Theorem, reasoning about geometrical ideas, transformations, spatial visualization, and angles in polygons (Dick & Burrill, 2009). Also, U.S. students' measures on international tests of achievement tend to be at the lowest level in geometry (Carnoy & Rothstein, 2013). Nearly all high-school teachers recognize that students rarely perceive a need for proof, and education researchers identify this result as a major issue in the teaching of geometry (de Villiers, 1999). Scholars have attributed the dilemma to two main factors: (1) "The foundation of most mathematics teachers in geometry is poor" (Adolphus, 2011, p. 143), and (2) geometry courses, as currently taught, do not help students develop an understanding of content but rather encourage memorization of definitions and theorems (Adolphus, 2011; Liu & Manouchehri, 2012).

Concurrently in the nation, the National Council of Teachers of Mathematics (NCTM) and the Common Core State Standards Initiative (CCSSI), with the goal of providing "an unprecedented opportunity for systemic improvement in mathematics education in the United States" (NCTM, 2014, p. 4), suggest "a foundation for the development of more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning as well as skill fluency" (NCTM, 2014, p. 4). In high school geometry, for example, the Common Core State Standards require more precise definitions and more rigorous proofs, the concepts of congruence, similarity, and symmetry learned from the perspective of geometric transformation, and the definitions of sine, cosine, and tangent for acute angles founded with the Pythagorean Theorem in many real-world and theoretical situations (NGA & CCSSO, 2010). Also, both NCTM and CCSSI strongly suggest the integration of technology such as dynamic geometry software into teaching. NCTM (2014) issued the following technology statement: "For meaningful learning of mathematics, tools and technology must be indispensable features of the classroom" (p. 78). NGA and CCSSO (2010) emphasize, "Dynamic geometry environments provide students with experimental and modeling tools that allow them to investigate geometric phenomena in much the same way as computer algebra systems allow them to experiment with algebraic phenomena" (p. 74). Dynamic geometry software such as the Geometers' Sketchpad (GSP) helps develop students' understanding of mathematical concepts and increase their reasoning skills (Conference Board of the Mathematical Sciences [CBMS], 2001). One of the benefits of dynamic geometry software is its dragging feature, which enables students to see "the universality of theorems in a way that goes far beyond typical paper and pencil explorations" (CBMS, 2001, p. 132).

Along with the widespread use of dynamic geometry technology, many related research studies (Baccaglioni-Frank & Mariotti, 2010; Hannafin, Burruss, & Little, 2001; Hollebrands, 2007; Myers, 2009; Vincent, 2005) have been conducted and shown that if dynamic geometry technology is used effectively, it can make a significant difference in students' learning. When used as a cognitive tool, it can facilitate students' explorations and investigations, support their conjecture making and verification, promote their logical reasoning, and enhance their conceptual understanding of various geometric ideas. Further, it provides teachers a strong means to engage their students actively in learning while using technol-

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