

## Chapter 17

# A Mathematical Problem–Solving Approach to Identify and Explore Instructional Routes Based On the Use of Computational Tools

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*To what extent do technology developments influence teachers' instructional practices? How can teachers incorporate mathematics education research into their learning activities? What types of mathematical and didactical knowledge becomes relevant for teachers to foster students' development of conceptual understanding, and problem-solving approaches? It is argued that a community of inquiry, formed by teachers, mathematicians, and mathematics educators, becomes important to examine and analyze in-depth mathematical tasks or problems. Interaction within this community is based on fostering an inquisitive or inquiring approach to identify, to make sense, and comprehend mathematical ideas, or relations, and to solve problems. Furthermore, the use of computational tools (dynamic software and hand-held calculators) could help teachers and students explore and analyze mathematical tasks in ways that can enhance and complement paper and pencil approaches.*

## INTRODUCTION

Mathematical problem-solving perspectives have framed and guided the development of multiple research programs, and supported curriculum proposals in mathematics education for the last four decades (Schoenfeld, 1985; 1992; NCTM, 2000).

Delving into the development of problem-solving research and discussing its influence in mathematics instruction requires the identification of core or fundamental issues; that is, an inquiry into problem-solving involves not only identifying themes and research directions, but also discussing the types of developments, changes and challenges that this field is facing today. What are the principles or common tenets that distinguish and unify research

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programs or instructional practices that are based on problem-solving approaches? To what extent have those principles evolved, been modified, or changed as a result of the development and use of computational tools? Focusing on these questions will help in characterizing and reviewing significant problem-solving developments as well as identifying key elements around the principles and possible identity of problem-solving as a domain and its corresponding academic agenda. Current themes and trends associated with problem-solving approaches document the extent to which the development of computational tools has influenced the development of research and problem-solving practices.

It is relevant to identify features associated with the characterization of problem-solving as a research and practice domain in mathematics education. Lesh & Sawojewski (2007) recognize that “the patterns that form a problem-solving identity are complex, involving varied motivational patterns, affective reactions, and cognitive and social engagement in different circumstances both within a given task and across tasks” (p. 776).

Does problem-solving in mathematics education have a common agenda, or does it have multiple themes and interpretations? Törner, Schoenfeld, & Reiss (2007) invited a group of educators who had been involved in problem-solving projects to document and discuss the influences and developments in their countries educational system. They asked them to elaborate three questions as a guide to present and structure their contributions: What are the major ideas in research? What are the main themes in curricula? And what are the relationships between research and curricula, as mediated by politics? The contributions in their publication included a variety of themes that involve the use of the terms problem and problem-solving, the study of teachers’ practices, students beliefs, and cognitive and metacognitive developments, the influence of problem solving in organizing the mathematics curricula, the relation between problem-solving

approaches and international assessments, e.g. Program for International Student Assessment (PISA), and the use of digital or computational tools in problem-solving activities. This multiple agenda illustrates numerous ways to utilize the construct of problem solving to investigate and promote students’ construction or development of mathematics knowledge.

This chapter does not intend to review the developments in the teachers’ education field and how they use problem-solving approaches (see for example, Sowder, 2007); rather, the inquiry focuses on ways in which the use of computational technology might offer a new avenue for teachers to revise, extend, and reflect on their mathematical and didactical knowledge for teaching. Thus, the focus of the chapter will be on extending a problem-solving framework proposed by Polya (1945) to include a systematic use of computational tools. To this end, a task is used to illustrate and discuss problem-solving episodes that are relevant to foster and structure the development of their students’ mathematical thinking.

## **BACKGROUND: TEACHERS’ EDUCATION AND PROBLEM SOLVING**

Current reforms in mathematics curricula recognize the importance for teachers to promote their students’ conceptual comprehension of mathematical content, and the development of problem-solving strategies. The National Research Council (NRC) (2001) suggests that teachers need to frame their instructional practices around five intertwined strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These activities are central for students to develop competencies in those strands, according to Spillane (2000, p. 144): “Reformers also propose that students develop a more sophisticated appreciation for doing mathematics including framing

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