Chapter 4

A Holistic Approach to Teaching the Process of Problem Solving: A Curriculum of Nonroutine Problems

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ABSTRACT

This chapter concerns an approach to teaching mathematics that facilitates the student seeing the connection between the process of solving nonroutine mathematics problems and solving significant problems in the student’s life. In this chapter, the author will define a nonroutine problem; discuss the concept of a curriculum of nonroutine problems; discuss a few examples of nonroutine problems, including some that facilitate the student seeing the connection between the process of solving nonroutine mathematics problems and solving significant problems in the student’s life; and suggest guidelines for implementing a curriculum of nonroutine problems consistent with improving the Common Core Mathematical Practices and the concept of reform-based mathematics education.

INTRODUCTION

Any reform-based mathematics curriculum needs to address the basic question, “What is essential in mathematics education?”. Certainly, such a mathematics curriculum must provide the average student with the tools to effectively address significant problems in that student’s life. This chapter concerns an approach to teaching mathematics appropriate for secondary and post-secondary students that facilitates the student seeing the connection between the process of solving nonroutine mathematics problems and solving significant problems in the student’s life. The approach is embedded in a curriculum of nonroutine problems field-tested from 1984 to 1995 in a secondary school setting, and later applied in an undergraduate mathematics course in problem-solving. The development and field-testing of the curriculum was based on a methodology for addressing significant problems in one’s context that require a transformation of understanding (London, 2016) — Perhaps an appropriate label for this methodology would be spiritual pragmatism, “A practical way of solving problems” (DeVinne, 1985, p. 973) without

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a fixation on views and theories, and with an understanding of the dynamics of the relationship between our inner work and our functional activities in the process of transformation. For this curriculum the development process consisted primarily of these steps: (1) The initial development of a curriculum appropriate for a high school Calculus course consisting of eight nonroutine problems, each requiring about two weeks work, primarily outside of class. The curriculum was viewed initially by the author as enrichment for the students with three of the problems connected to the Calculus curriculum (see London, 1989). The unexpected significance of the curriculum was described thusly,

*The significance of the curriculum can probably be best described by reporting the observed effect on the mathematical maturity of the students. It is as if the student has been transformed mathematically! Instead of acting in all the ways that we normally attribute to most high school students, the student acts similarly to a ‘mathematically mature’ person. For example, instead of stopping when an obstacle is encountered, the student will persist. Instead of ignoring obvious contradictions or inaccuracies, the student will actively examine them. Instead of being intimidated by ambiguity, the student will tolerate the ambiguity. Instead of being satisfied with the first solution to a problem, the student will work on a problem until a more satisfactory solution is reached. Instead of staring at a problem that seems unsolvable or confusing, the student will try something until the problem naturally becomes clearer.* (London, 1989, p. 1)

(2) The development of a four-year curriculum by the author, consisting of 60 nonroutine problems in seven strands, fifteen per year, suitable to be integrated into a four-year secondary academic mathematics curriculum. Development of the curriculum was primarily completed during a ten-week Alden B. Dow summer residential creativity fellowship. (3) The field-testing and revision of the curriculum in all the mathematics courses at Old Saybrook High School in Old Saybrook, Connecticut (an upper middle-class shoreline community) for which the author was the mathematics department chair. This field-testing included the author’s one-year elective course Problem Solving, which allowed for more in-depth field-testing. (4) The further development and revision of the curriculum as a professor of education at California State University, San Bernardino, including the teaching of an undergraduate liberal studies one-quarter mathematics course in Problem Solving and field-testing of the curriculum by four graduate students (e.g., DeLeon, 2003). It should be clear that the methodology is primarily classroom-based research versus an empirical research study. Specifically, the methodology was appropriate for the development of a curriculum effective for the author’s professional context, but not necessarily generalizable to other classrooms. In fact, it is the author’s opinion that the curriculum requires an educator that is able to adjust the curriculum to be appropriate for the educator’s context, including being sensitive to unique nonroutine problems meaningful for the educator’s students.

In the rest of this chapter, the author will define a nonroutine problem; discuss the concept of a curriculum of nonroutine problems; discuss a few examples of nonroutine problems, including some that facilitate the student seeing the connection between the process of solving nonroutine mathematics problems and solving significant problems in the student’s life; and suggest implications for implementing a curriculum of nonroutine problems consistent with the concept of reform-based mathematics education.