

ASSESSING THE NCATE/NCTM STANDARDS FOR PRESERVICE SECONDARY MATHEMATICS TEACHERS THROUGH PORTFOLIOS

Pete Johnson
Eastern Connecticut State University
Mathematics and Computer Science Department
83 Windham St.
Willimantic, CT 06226
johnsonp@easternct.edu

Introduction

In 2003, the National Council for Accreditation of Teacher Education (NCATE) and the National Council of Teachers of Mathematics (NCTM) collaborated to create a set of Standards for programs seeking accreditation in secondary mathematics. This set of 16 Standards (NCATE, 2003) indicates what teacher candidates in secondary mathematics education are expected to know, the dispositions they are expected to have, and the experiences expected as part of their undergraduate preparation to teach. Each Standard lists from 1 to 10 Indicators used to demonstrate that candidates meet that Standard. Thirteen of the Standards concern either mathematical content candidates should know (hereafter referred to as the Content Standards) or the mathematical processes with which candidates should be familiar (hereafter referred to as the Process Standards; the other Standards were assessed at Eastern by other means and are not considered further in this paper). Institutions seeking accreditation in secondary mathematics are required to provide data demonstrating that their candidates meet these Standards. Specifically, institutions are required to demonstrate that their teacher candidates meet 80% of the Standards and 80% of the Indicators listed under each Standard.

This paper describes the process that the author, along with a colleague (Dr. Hari Koirala) in the Education Department, undertook in order to assess our secondary mathematics teacher candidates and provide the data required for NCATE/NCTM accreditation. We have developed both a course in which the Standards could be addressed and a portfolio assignment and scoring rubric for assessing our secondary mathematics candidates. In what follows, I will describe what has been done at Eastern in terms of portfolio assessment; share some of the results that characterize the portfolios collected in the pilot test, conducted in the Spring 2006 semester; and describe some of the next steps taken to revise and improve the portfolio assessment system, based on the pilot test. I will use the Technology Standard as an example throughout this paper, although it is important to note that the portfolios and scoring rubric address all of the Content and Process Standards.

Portfolio Assessment at Eastern

There were two major components to the effort at Eastern to assess our secondary mathematics candidates and to collect the data necessary for NCATE/NCTM accreditation. The first was the development of a new course, called Advanced Mathematics for High School Teaching, that serves as a sort of capstone course for secondary mathematics candidates (it is not a “traditional” capstone course, as candidates will ordinarily take it in the Spring semester of their junior year of study). In the future, those who are unable to complete the mathematics portfolio assignment successfully will be unable to continue in secondary mathematics education (although unacceptable entries are returned to the candidates, who are then asked to revise and resubmit them; this procedure was not used during the pilot test in the Spring of 2006). Candidates taking the course in the Spring semester of their junior year at Eastern will ordinarily have completed most of the mathematical content courses required for their major, with the exception of Real Analysis (a one-year course which is the capstone of their mathematical study).

The main emphasis in the Advanced Mathematics for High School Teaching course is the integration of the content from courses in the mathematics major, and considering the content of secondary mathematics from an advanced standpoint. The textbook for the course is Usiskin, Peressini, Marchisotto, & Stanley (2003). The course also includes a review of the material needed for candidates to take the Praxis II: Mathematics Content Knowledge exam (Educational Testing Service, 2003). Review of other topics are incorporated into the course as needed (for example, candidates entering the course often need some guidance for the Standards that include the history of mathematics, as Eastern has no permanent course in the history of mathematics).

A second component of this project was the development of the portfolio assignment and scoring rubric used to assess candidates’ portfolios (copies of these and other materials mentioned in this article are available from the author). The portfolio assignment was the major assignment in the course. This portfolio should demonstrate that candidates meet the Standards and Indicators listed in the NCATE/NCTM Standards. Candidates were urged to use problems they had completed in other courses as a starting point. These problems should be expanded into portfolio entries with the addition of a written commentary showing how the problem demonstrated the candidate’s understanding of mathematics, the processes used to complete the problem, and the connections between this problem and the teaching of secondary mathematics.

A scoring rubric was developed for assessing the portfolios. Candidates received a score for each of the thirteen Process and Content Standards, on a scale from 0 (Unacceptable) to 3 (Target). The initial version of the scoring rubric focused on the number of entries a student should submit for each Process and Content Standard and their quality. For example, the rubric for evaluating the Technology Standard (#6 in NCATE, 2003) is shown in Figure 1. The language in the rubric used to assess other Standards was similar.

| | Target (3) | Acceptable (2) | Unacceptable (0-1) |
|------------------------|--|--|---|
| Technology (#6) | Uses knowledge of mathematics to select and use appropriate technological tools, such as but not limited to, spreadsheets, dynamic graphing tools, computer algebra systems, dynamic statistical packages, graphing calculators, data-collection devices, and presentation software. | Uses knowledge of mathematics to select and use at least 80% of the following technological tools: Spreadsheets, dynamic graphing tools, computer algebra systems, dynamic statistical packages, graphing calculators, data-collection devices, and presentation software. | No evidence of appropriate technological tools. |

Figure 1: Portfolio Rubric, Technology Standard

Results

The Advanced Mathematics for High School Teaching course and the scoring rubric for assessing the mathematics portfolios were both pilot tested in the Spring of 2006. Each portfolio was evaluated independently by two raters, myself and Dr. Hari Koirala from the Education Department. As a part of our analysis, we evaluated the interrater consistency for the two sets of scores. For the portfolio as a whole, our scores agreed 42% of the time, and the correlation coefficient between the two sets of scores was $r = .565$ ($p < .001$). The Spearman rank correlation coefficient between our overall rankings of candidates was $r = .696$ ($p < .001$). This level of agreement seems to show reasonable interrater consistency for a pilot test.

Candidates' scores were higher in the Technology Standard than in any other Standard. One rater had a mean score of 2.19 and the other a 2.38 for the 21 candidates completing the portfolio assignment in the Spring 2006 semester. Candidates at Eastern see a wide range of software packages in their mathematics courses: in addition to the TI-89 calculator and a course in Programming, all candidates use Minitab (in Applied Data Analysis), Geometer's Sketchpad (Geometry) and Maple (Calculus) in required courses. Thus it is perhaps not surprising that candidates had a wide range of examples to choose from to develop portfolio entries in this area.

While we were pleased with our candidates' performance in the area of Technology, we were not as pleased with the quality of the portfolios as a whole. The mean scores for the portfolios as a whole were 2.12 for one rater and 1.62 for the other rater; which means that a number of portfolios had an average rating of below 2.00, considered "acceptable" (five of the 21 portfolios had a mean rating below 2.00 from both raters). Upon reviewing the scores and the content of the portfolios, we formulated several categories that characterize candidates' work in the portfolios:

- Candidates made few connections between mathematical content areas, and between Content and Process Standards.
- Too many “small” problems were selected; many entries contained problems that were merely “Exercises” and did not show a rich, interconnected understanding of mathematics.
- Many problems selected were too elementary, not college-level mathematics.
- Candidates focused too much on using problems in teaching high school, not enough on demonstrating their own understanding of mathematics

We are currently carrying out further research on candidates’ portfolios to see what claims can be made about our teacher candidates’ understanding of mathematics and views on teaching secondary mathematics.

Next Steps

The Advanced Mathematics for High School Teaching course, the portfolio assignment, and the scoring rubric have been extensively revised based on the results of the pilot test. For example, I believe that the Spring 2006 course might have sent “mixed messages” to candidates about the portfolio assignment. While we undertook a variety of activities during class time, we did spend a lot of time reviewing Praxis II-type problems in the course. Since this exam is a strictly timed exam (50 questions in 120 minutes), the kinds of questions on Praxis II cannot show rich interconnections between mathematical content areas; yet many candidates used these problems in their portfolios. The timing and amount of review for the Praxis II exam has been shifted so that most of it occurs toward the end of the course, after candidates have a better understanding of the portfolio assignment.

The portfolio assignment itself has been very extensively revised as well. In the pilot test, candidates were asked to provide two examples for each of the Indicators listed in the Standards. This probably was partly responsible for candidates’ focus on “small” or “exercise”-type problems and not on the interconnectedness of mathematics. Accordingly, the assignment was changed so that each student was to include six entries, with each one showing a range of Standards and Indicators. The six entries are described as Number Systems, Algebraic Structures, Shape and Measurement, Function, Discrete Mathematics, and Data Analysis and Uncertainty. Most of the Content Indicators are “tied” to a particular entry, and the candidates are free to show the Process Indicators in whatever entry seems to best demonstrate that Indicator. For example, the indicator for Technology can be demonstrated in any of the six entries.

Finally, the scoring rubric has been revised to match the new version of the portfolio assignment. Instead of separate wording for each Standard, there is only one version which is used to evaluate each Standard. The new scoring rubric is shown in Figure 2.

Target (Score 3: Evidence of exceptional performance, beyond what one would typically expect of a mathematics major.)
 The student demonstrates: a) in-depth knowledge and comprehensive understanding of the mathematics content and processes from the NCATE/NCTM standards and indicators, with no significant mathematical errors, b) an ability to reflect deeply on and communicate

clearly, logically, and elegantly about the mathematics included in the standards and indicators, c) an inherent connection among multiple mathematical content areas and processes, and d) how college level mathematics is connected to the teaching of high school mathematics.

Acceptable (Score 2: Evidence of satisfactory performance and above.)

The student demonstrates: a) a solid knowledge and understanding of the mathematics content and processes from the NCATE/NCTM standards and indicators, although some mathematical errors may occur, b) an ability to reflect on and communicate clearly and logically about the mathematics included in the standards and indicators, c) some connections among multiple mathematical content areas and processes, and d) some connections between college and high school mathematics.

Unacceptable (Score 1: Unsatisfactory performance)

The student demonstrates at least one of the following: a) a lack of knowledge or understanding of the mathematics content and processes from the NCATE/NCTM standards and indicators or substantial mathematical errors related to the standards and indicators, b) a lack of ability to reflect on or communicate logically about the mathematics included in the standards and indicators, c) no connections between two or more mathematical content areas and processes, or d) no connections between college and high school mathematics.

Missing or Difficult to Make Sense (Score 0: Unsatisfactory)

The student does not provide any response or the response provided is extremely hard to interpret or make sense.

Figure 2: Revised Portfolio Scoring Rubric

The course is presently being taught in the Spring 2007 semester. The data from these portfolios will form an important part of the data submitted to NCATE for accreditation of the secondary mathematics program. Early indications, from feedback from candidates taking the course, is that the revised portfolio assignment and scoring rubric will result in a significant improvement in the quality of the portfolios, and will assist candidates in drawing the connections between topics in different mathematical areas and between college and secondary mathematics. The results from the Spring 2007 portfolios will be analyzed and disseminated in the mathematics education literature.

References

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