

Including Awareness of Assessment Issues in Teacher Content Preparation

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Abstract

The work of mathematics teachers from kindergarten through post-secondary levels most certainly involves classroom assessment of student learning. Yet at what points in a teacher preparation program do preservice teachers learn to plan assessment, gather evidence, interpret evidence and use the results of assessment? How well prepared are beginning mathematics teachers to use assessment to monitor student progress, to make instructional decisions and to evaluate students' achievements? This paper reports on assessment workshops for instructors who prepare preservice teachers as well as for preservice and inservice teachers. The workshops are based on National Assessment of Educational Progress (NAEP) materials (Brown & Clark, 2006) recently published by the National Council of Teachers of Mathematics and a free website (<http://nces.ed.gov/nationsreportcard/>). Workshop participants examine released NAEP items in multiple choice and open-ended formats, multiple-choice distractors, scoring rubrics for open-ended problems and actual pupil responses. Improved instruction informed by assessment is a main goal.

Introduction

The statement, "So much to do in so little time!" characterizes discussions of the mathematical content to be taught to preservice elementary school teachers. Earnest discussions continue regarding exactly what mathematics and what pedagogical content knowledge is central to graduating new elementary teachers well equipped to facilitate children's mathematics learning. Eron and Rachlin (2005) make the statement that a teacher preparation program "should address the development of five types of knowledge: *Knowledge of Mathematics, Knowledge of the Teaching of Mathematics, Knowledge of the Learning of Mathematics, Knowledge of the Learner of Mathematics, and Knowledge of School Mathematics.*" (p. 1)

This paper presentation reports on one aspect of a National Science Foundation-funded grant for mathematics, science, and education instructors charged with enhancing the first two years of teacher education programs in East Tennessee. It was noted that new teachers often have virtually no exposure to assessment issues such as how to assess student learning before, during and after instruction with an eye to improving instruction. These new teachers and their pupils will also be judged by high stakes tests sponsored by the state and the nation. Likewise, the mathematics instructors in charge of content courses for preservice teachers may have had no formal exposure to assessment issues themselves. The solution was to conduct a two-day workshop for grant teacher preparation instructors using a recent publication from the National Council of Teachers of Mathematics (Brown & Clark, 2006). This publication presents high-quality professional development activities using National Assessment of Educational Progress (NAEP) materials. The activities on how assessment data relate to student learning in mathematics classrooms can be modified for a variety of audiences. Grant instructors have incorporated assessment workshop materials in mathematics content and pedagogy courses and have conducted workshops for preservice and inservice teachers.

Using NAEP Materials to Enhance Knowledge of School Mathematics

NAEP is the only nationally representative and continuing assessment of what United States students know and can do in various subject areas, including mathematics, reading, science, writing, history, civics, geography, and the arts. It is a congressional survey of educational achievement to get a sense of progress for the nation as a whole. Mathematics was assessed in 1973, 1978, 1982, 1990, 1992, 1996, 2000, 2003 and 2005. NAEP provides a snapshot of 4th, 8th and 12th grade performance. Therefore, it reflects school mathematics curriculum in the United States across a time span of more than 30 years.

The NAEP materials are particularly valuable in helping teacher preparation instructors build knowledge of school mathematics in content courses for preservice teachers who will teach kindergarten through 8th grade. The mathematical background of preservice teachers should be considerably deeper than what they will teach. Therefore, teacher preparation instructors must be well versed in what the National Council of Teachers of Mathematics (NCTM) has set as standards and how curriculum developers have interpreted the standards. The NAEP materials include assessment items from five content areas of school mathematics: (1) Number Sense, Properties and Operations, (2) Measurement, (3) Geometry and Spatial Sense, (4) Data Analysis, Statistics and Probability and (5) Algebra and Functions. It is particularly helpful for both instructors and their preservice teachers to examine how well 4th and 8th grade students have done on individual items. In this way, it is possible to determine what aspects of the school mathematics curriculum present difficulties for pupils.

Here is one activity that illustrates how NAEP materials may be used to enhance knowledge of school mathematics. A workshop leader selected 10 items from the Number Sense category at the 4th grade level. According to the NAEP framework, a typical 4th grade student should have encountered the conceptual understanding, procedural knowledge and problem solving involved in these items by the 4th grade. Workshop participants answered the items and ranked them from easiest to hardest based on their perception of 4th graders thinking. Here is one item participants thought that 4th graders would have little difficulty answering:

Amber and Charlotte each ran a mile. It took Amber 11.79 minutes. It took Charlotte 9.08 minutes. Which number sentence can Charlotte use to best estimate the difference in their times?
A) $11 - 9 =$
B) $11 - 10 =$
C) $12 - 9 =$
D) $12 - 10 =$

Participants were surprised that 4th graders found the item quite difficult. Only 33% of 4th graders in a representative national sample chose the correct answer of C. The most popular distractor was A with 51% of the sample choosing it. A productive discussion followed on student conceptions and misconceptions involving estimation, decimal representations, rounding and subtraction.

The National Center for Educational Statistics maintains the NAEP Web site (<http://www.nces.ed.gov/nationsreportcard/>). The online tools at the site make it easy for professional development organizers and teachers to select assessment items by grade level (4th, 8th, 12th), content classification, and difficulty level. Each item comes with performance data as well. Both instructors preparing preservice teachers and inservice teachers build awareness of school mathematics as they work with NAEP items and accompanying data.

Using NAEP Materials to Enhance Knowledge of Mathematics

NAEP has three item formats. The previous section used a 4th grade item in multiple-choice format having four choices. The 8th and 12th grade items have five choices. The other two formats are short constructed response and extended constructed response. Here is an activity that illustrates how an extended constructed response may be used to enhance knowledge of mathematics in a content course for preservice elementary teachers. The 4th grade item below relates to making sense of fractions.

Think carefully about the following question. Write a complete answer. You may use drawings, words and numbers to explain your answer. Be sure to show all of your work.

Josè ate $\frac{1}{2}$ of a pizza.

Ella ate $\frac{1}{2}$ of a pizza.

Josè said that he ate more pizza than Ella, but Ella said they both ate the same amount. Use words and pictures to show that Josè could be right.

In the activity, preservice elementary teachers are asked to follow the instructions and produce a complete answer that would be understandable to a 4th grader. The item can be administered as a pretest item before preservice teachers have covered a unit on rational numbers to assess prior knowledge or as a posttest item to assess pedagogical content knowledge. It is valuable to score the responses of preservice teachers using the NAEP scoring guide:

Extended--Student fully explains and mentions relative size of the pies. (Must say Josè's is larger.)

Satisfactory--Gives a picture where sizes are different, but gives no explanation.

Partial--Statement such as "Josè's pizza had bigger pieces."

Minimal--Student answers $\frac{1}{2}$ is always equal to $\frac{1}{2}$. OR refers to the relative number of pieces of pizza,

or toppings.

Incorrect/Off Task--The work is completely incorrect, irrelevant, or off task. e.g., a picture without a comparison with pizzas appearing about the same size.

This item is not particularly easy for 4th graders in that 67% scored minimal or incorrect/off task in 1992. In 2006, a college instructor administered the item in a mathematics content course for elementary teachers and found that 28% of the preservice teachers scored minimal or incorrect/off task. A clear implication for instruction is that some preservice teachers and many 4th graders need experiences with multiple representations of rational numbers including comparisons of halves of different sized objects. A follow up discussion for preservice teachers can focus on which mathematics manipulatives and activities are effective in representing fractions of different sized objects. The discussion helps preservice teachers become aware that the commonly used fraction circle sets only illustrate various fractions of a single-sized whole. In the grant workshops, we encouraged instructors to use NAEP items to assess content knowledge and modify instruction based on the strengths and weaknesses in school mathematics revealed by preservice teachers' responses.

Using NAEP Materials to Enhance Knowledge of the Learning of Mathematics and the Learner of Mathematics

A particularly effective aspect of the Brown and Clark (2006) NAEP professional development materials can be found on the CD, which comes with the book. For a large number of extended response items, the author team assembled 20 or more interesting 4th and 8th grade pupil responses to each item. The NAEP website offers only a small number of pupil responses to

illustrate each scoring level, so the CD enriches the collection. These responses afford deep insight into the mathematical conceptions and misconceptions of pupils.

There are several approaches to engaging preservice and inservice teachers in exploring pupil thinking as revealed in responses to open-ended NAEP items. After the teachers have written their own responses to an item such as the pizza problem presented in the previous section, they can think-pair-share prompted by the following questions:

1. How do pupils at this grade level approach this test item?
2. What errors or misconceptions do students hold?
3. What mathematical knowledge is necessary to solve this problem?
4. What does the test item reveal about student's understanding?

A productive next step is to have teachers decide which answers are more correct than others as they sort all responses on a continuum from unsatisfactory to exemplary. Additional questions to prompt discussion are as follows:

1. What do you think children knew or did not know that made their answers the same or different from yours?
2. Were you surprised by any of the answers?
3. What makes some solutions "more correct" than others?

The fact that actual pupils answered the NAEP items in such a variety of ways invites active participation in the activities.

Another way to initiate a thorough discussion is to ask teachers to select four responses from different places along the continuum from least correct to most correct. Teachers examine the four responses and fill out a form that focuses on the concrete evidence of understanding or misunderstanding as seen in a child's work. (This form, a variety of other handouts, and modifiable presentation slides come ready to print out from the CD.) This evidence is used to conjecture about what a child does or does not understand. Preservice teachers especially benefit from discussing how to help students take the next step in their learning based on what the assessment item reveals. As classroom teachers, their instruction will improve as they make changes in response to evidence they gather from focused assessment items. These materials allow preservice teachers to practice on actual student responses prior to having access to students in their own classrooms.

An important end result of activities using open-ended NAEP items is to increase the likelihood that teachers will incorporate more open-ended problem solving in their teaching. It is useful to point out that "a problem is, by definition a situation that causes disequilibrium and perplexity." (Lester & Charles, 2003, p. 7) Indeed, NAEP items often produce some disequilibrium and perplexity in workshop participants. As a formative workshop assessment, it is valuable to supply writing prompts to participants and 5 by 8 index cards. When asked what she learned in a NAEP workshop, a 4th grade inservice teacher replied that she learned about the "use of more open-ended questions", that "students need to answer more with written explanations and pictures" and that "pictures can show a lot about student misconceptions." It isn't easy for inservice and preservice teachers to pose open-ended questions of their own making. They have responded very positively to the free NAEP Web site as a resource for both open-ended and multiple-choice items that elicit problem solving thinking on the part of their pupils.

Using NAEP Materials to Enhance Knowledge of the Teaching Mathematics

The mathematics, science, and education instructors in the grant described at the beginning of this paper were charged with enhancing the first two years of teacher education programs in East Tennessee. In a two-day workshop, they examined released NAEP items in multiple choice and open-ended formats and what these items reveal about the understanding of 4th and 8th pupils in mathematics and science. They worked with a new scoring method called Extended-Multiple-

Choice as a means of determining what distractors reveal about misconceptions. They scored pupil responses to open-ended items using NAEP scoring rubrics. They predicted the difficulty level of NAEP items and the effectiveness of multiple-choice distractors and compared predictions to national data. They learned to use a free website to extract NAEP items and left the workshop with an assignment to select and administer appropriate items in a class they were teaching Spring Semester, 2007. They reported back on the assignment at a workshop in May 2007. The two days were a hands-on crash course in assessment issues done in a workshop format rather than by lecture.

The workshop made use of two outside consultants. One consultant co-chaired the framework committee for the 2009 NAEP Science assessment. The other consultant is a co-author of a chapter in Brown & Clark (2006). Both commented on the enthusiasm and active participation of grant faculty. Here is an evaluative quotation from one consultant: "This is, of course, not a formal evaluation, but I think the workshop really succeeded in making faculty aware of the existing assessment resources and how they could be used to better prepare preservice teachers regarding assessment of pupil knowledge and skills in science and math."

Chapter 7 of the Brown & Clark (2006) publication proposes several workshop activities that address the wide-ranging and complex issues of assessment. One activity asks participants to sort NAEP assessment items using a specific framework. The focus of the sort is the types of student thinking different items elicit. The framework uses the following categories:

- Requires students to recall a memorized fact
- Requires students to perform a procedure
- Requires students to use reasoning to find an answer (a procedure may exist, but it cannot be used mindlessly)
- Requires students to use reasoning to find an answer *and* to justify their reasoning

This activity leads participants to think deeply about the characteristics of items and tasks. There are also activities on creating and using rubrics. For instructors who may have had little previous exposure, the two-day workshop was a quick initiation into how to incorporate assessment issues in teacher preparation and why awareness of assessment issues is important to the work of a teacher.

Summary

This particular approach to professional development on NAEP has been applied to workshops for instructors involved in teacher preparation, for preservice teachers, and for inservice teachers. The NAEP Web site is free. Though it is in English and has data only on administration of items in the United States, the mathematics items bear some resemblance to TIMSS and other international assessments. The *Learning from NAEP* (2006) publication contains a CD with hundreds of examples of pupil work on open-ended items as well as a number of workshop presentation slides that can be used as is or modified to suit different audiences. There is a cadre of facilitators now trying out the materials on a variety of audiences. There are formal studies in progress as to the uses and effectiveness of the professional development materials.

References

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