Elementary Mathematics Pre-Service Teachers' Learning from Cases

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The use of cases in pre-service teacher education programs has increased dramatically in the past decade. Cases and case discussions are viewed widely as powerful tools for engaging teachers in serious reflection on the complexity of classroom life (Henningsen, et al., 2000; Kleinfeld, 1992; Sykes & Bird, 1992; Richert, 1991). Definitions of what a case is vary in the teacher education literature, but most would agree that cases are representations of authentic practice that may be used a site for inquiry and reflection. Cases may represent large or small chunks of teaching, they may be authored from a variety of perspectives, and they may or may not be designed to highlight specific issues or be exemplars of particular practices. Cases are embodied in a variety of forms including video, audio, narrative re-telling, CD-ROM, transcripts and other artifacts and records of practice. The use of such tools is consistent with recent calls for practice-based professional development in mathematics (Smith, 2001; Ball & Cohen, 1999; Barnett, 1998). At the same time, relatively little research has been conducted on what mathematics teachers actually learn from the experience of reading, analyzing, and reflecting on cases.

The purpose of the present study was to explore the following research questions: 1) What do elementary pre-service mathematics teachers say they have learned when they are asked to reflect back across a set of narrative and video cases they have read and analyzed previously; and 2) To what extent does learning across cases differ for pre-service teachers who provide differing levels of evidence in their reflective statements? In other words, do pre-service teachers who more consistently and explicitly ground their reflections in evidence from the cases seem to learn different lessons from reading and analyzing cases than pre-service teachers who do not consistently ground their reflections in evidence from the cases.

Participants and Context

Participants in the study were 28 pre-service teachers enrolled in a practicum course in teaching elementary mathematics at the American University of Beirut. The course was designed to highlight reform-oriented approaches to teaching mathematics. The pre-service teachers were in their final semester of a B.A. program in Elementary Education that also leads to a teaching certification. All participants were female with an average age of 21. They were also engaged in their student teaching practica in mathematics and science simultaneously with taking this course. All participants had also completed a previous course in methods for teaching mathematics at the elementary school in the semester just prior to taking the practicum course. Participation in the study was voluntary.

During the practicum and prior methods course pre-service teachers were engaged in reading and analyzing several narrative and video cases of elementary mathematics teaching. Each case depicted a real example of teachers and students trying to enact a rich mathematical task that would engage students in high-level thinking, reasoning, and communication. The cases were generally used to bring to life issues of pedagogy both in general and in specific contexts of teaching particular mathematical topics. Cases were also used to broaden preservice teachers' experiences beyond their school placement by engaging them with examples of teaching from several different grade levels. The narrative cases used were drawn primarily from the QUASAR project (see Stein, et al. (2000), and the COMET project (eg., Smith, et. al, 2005). Normally, preservice teachers were first engaged in a mathematical task related to the case prior to reading the case. They were also asked to analyze each case, write about them, and to discuss them in small groups and with the whole class. The video cases used were all drawn from the Teaching Math K-4 series produced by Annenburg/CPB in the 1990s. These cases were usually viewed with the whole class, discussed in small groups and with the whole class. Some of them were also used for major analysis projects in the methods and practicum courses. The specific cases used in the courses taken by the participants in this study are summarized in Figure 1 below.

Data Sources

Data for the present study were drawn from a written writing assignment completed toward the end of the course in which participants were asked to reflect back across all the narrative and video cases they read and analyzed throughout the entire year (across two courses) and to discuss similarities and differences

Case Name	Source	Math Topic(s)	Other Features
Lady Bugs	Annenburg/CPB	Data	Bilingual instruction; building math language; writing in math; concrete materials from natural environment; pair work; recording/compressing data; multiple representations; math-science integration
Woodpecker	Annenburg/CPB	Statistics and Sampling	Integration; unifix cubes; group work; probability simulation; recording ideas; data interpretation
Shapes from Squares	Annenburg/CPB	Geometry/Spatial Sense	Group work; building math language; bilingual instruction; on-line assessment interviews; recording ideas; concrete materials; connections to prior experience
People Patterns	Annenburg/CPB	Repeating Patterns	Acting out ideas; building math language; multiple representations; group work management
Caps for Sale	Annenburg/CPB	Number Sense	Learning centers
Nicole Clark	QUASAR	Data	Students select their own topic; slippage from high to low level; building self-esteem; keeping the focus on math in discussions
Fran Gorman & Kevin Cooper	QUASAR	Fraction Multiplication	Pattern blocks as area model for multiplication; pair work; slippage from high to low; maintaining high level; eliciting student thinking; collaboration with colleagues; two teachers, same task
Randy Harris	COMET	Connecting Fractions, Decimals,and Percents	Reasoning with diagrams; multiple solution strategies
Catherine Evans & David Young	COMET	Algebraic Thinking	Pattern blocks; growing patterns; building formulas; meaning of "success" in math; two teachers, same task
Isabelle Olson	COMET	Measurement/Problem Solving	Open-ended problems; "covering the curriculum" ; multiple solution strategies/representations; generalization; use of homework
Robert Carter	COMET	Graph Interpretation	Writing in math; misconceptions; multiple strategies; use of homework
Janice Patterson	COMET	Ratio and Proportion	Use of diagrams; multiple strategies

Figure 1. Summary of cases used in the methods and practicum courses.

across the cases, the big ideas they think they learned from the cases, and which case(s) they found the most useful for their own learning and why.

Data Coding and Analysis

For each response, the number of cases considered in the response was recorded. The number ranged from two to eight, with a median number of five. The substantive coding process drew on elements of grounded theory coding (Strauss, 1987). The procedure consisted of dividing each response paper into reflective idea chunks typically consisting of two to five sentences related to particular idea, including elaboration and justification, if any. Each idea chunk was then coded as to whether it was evidence-based or not, i.e., explicitly and appropriately grounded in specific cases. Each idea chunk was also coded into one of the following original content categories depending on the explicit content: TM-Teacher's role in teaching math or how to teach math (including planning and assessment); TG-General statements about teacher role or how to teach (this category was eventually collapsed with TM because it represented only 7% of all teaching-related idea chunks); M-Mathematical ideas or processes learned; S-Student role in learning math; C-Value of studying cases or looking across cases. Idea chunks that repeated ideas that were already recorded elsewhere in the response paper were not coded. The codes for each response were organized into a table showing the number of idea chunks in each coding category for each response, the total number of idea chunks, and the number of evidence-based idea chunks. For each response, the percentage of idea chunks that were evidence-based was calculated and added to the table. In addition, the frequency of specific comments in each coding category were also recorded and tabulated across all the responses. In order to answer the second research question, the percentage of evidence-based idea chunks were used to sort the responses into categories of High (75% or higher), Medium (50-74%), and Low (49% and below). This sorting was organized into a table to look for patterns.

Results and Discussion

The first research questioned focused on what pre-service teachers said they learned from reading and analyzing the collective set of cases. Overall there were 308 idea chunks coded across the 28 responses. Of those, 233 (75%) were about Teachers/Teaching, 36 (12%) were about Students/Student Learning, 15 (5%) were about Mathematical Ideas, and 24 (8%) were about the value of Cases. The primary focus on the role of the teacher or pedagogical ideas was not surprising considering that the pre-service teachers wrote these reflections while nearing the end of an intensive two-semester sequence of courses focused mainly on pedagogy in elementary mathematics. However, if we look at the specific comments about what they learned, we can see that in fact many of the respondents viewed the pedagogical ideas they were learning from the point of view of student learning. Figure 2 shows the comments in each category that were cited by more than one participant.

Teacher role/ Teaching Math	Student role/Student Learning	Mathematical Ideas	Value of Cases
Observe/Elicit student thinking/explanations /justifications (26) Importance of using high-level math tasks (25) Group work/as a means of communication (17) Emphasize multiple solution strategies/perspectives (15) Establishing clear performance expectations (13) Use of concrete materials and diagrams (11) Ways tasks can slip from high to low (11) Use informal	Students can and should communicate with/explain to/debate with each other (21) Students can explore concepts and make sense on their own/shouldn't underestimate this (14) Teacher knowledge can affect students' opportunity to learn (5) Succeeding on challenging tasks builds confidence (3) Open-ended tasks can trigger students' curiosity (2)	Various specific topics mentioned (eg., representing patterns visually; significance of data collection/interpretation; improved spatial sense; proportions; relating geometry and measurement) (8) Looked at familiar concepts from new perspective (4) Problems with no numbers scared me, but now I can handle it (2) Doing mathematics takes time (2)	Cases show different ways of handling different kinds of math tasks (10) Cases are tool for learning to teach (6) Important to see both ups and downs (2) Engage in critical analysis and investigation (2) Cases show what's possible (2) Cases show that good tasks are not enough, it's more complicated (2) Sometimes it's hard to enact your beliefs, helps to understand that (2)

assessment/interviews during class (10) How to run class discussions (10) Planning appropriate tasks for groups of students (9) Importance connections, real world, and among math ideas (9) Maintaining task complexity/scaffolding (7) Try to integrate subjects when possible (7) Building on prior knowledge (6) Success does not equal understanding (5) Hold students accountable for good explanations (5) Using homework in different ways (4) Sociomathematical norms (4) Teachers need to self-assess (4) Assigning sensible group roles (3) Building self-esteem, confidence in ability to do math (3) Safe environment (2) Unexpected things can happen when you use high-level tasks (2) Importance of sharing with colleagues (2)			

Figure 2. Comments in each category cited by more than one participant

As shown in the figure, the highest number, 93% of the pre-service teachers in this study, explicitly stated that the cases helped them understand that as a teacher they are obligated to observe student thinking by asking questions that elicit student explanations and justifications. The second most often cited element (89%) was the importance of engaging students in high-level tasks, or tasks that require high-level thinking, reasoning, problem-solving and communication. Many of the respondents elaborated that the cases made them realize that it is important to use such tasks on a regular basis in order to develop these skills in students. Seventy-five percent said they learned that students should be explaining to each other and debating with each other and that such activity promotes mathematical learning. Also 50% of the participants articulated that the cases made them realize that they should not underestimate students' abilities to explore mathematical concepts and make sense of them on their own. Some of them further articulated that traditionally it is assumed that students have to be shown and told everything, but that they saw many examples across the cases of good thinking and reasoning by students and that students can probably do much more than adults traditionally think. Overall, the participants clearly indicated that studying the cases drew their attention to the importance of children's mathematical thinking and communication and to the kinds of tasks and questions that might reveal or make explicit how children

think so that teachers may respond to children appropriately. This aspect became of prime importance for most of the respondents, rather than just another thing in a long list of "what teachers should do."

The fourth and fifth most cited elements were also articulated as they related to eliciting and supporting student thinking. Seventy-one percent of the respondents discussed group work as something they learned about from the cases, but the particular way they talked about it was interesting. Out of the 20 who featured this idea in their reflections, 17 said that they learned different ways to use group work in the classroom specifically as a tool or means to promote communication among students and by students in the classroom. Many elaborated that the cases made them realize the value of student-to-student communication and the role it could play in students' learning processes. Finally 54% also said they learned how important it is to encourage the use of multiple solution strategies and representations, or promoting the idea of looking at mathematical concepts from multiple perspectives. They cited many examples from the cases of where discussions of multiple solution strategies and representations seemed to promote good discussions and led to better student understanding.

Finally it is interesting to note that more than one-third of the participants discussed specific mathematical ideas or new insights about mathematics that they feel they learned from studying the cases. Additionally a few respondents also mentioned that they learned about how the teacher's knowledge can affect children's opportunities to learn mathematics. These findings support the idea that studying cases of mathematics teaching can be a useful tool for bridging the gap between pedagogical knowledge and content knowledge (Ball, 2000; Shulman, 1986). Cases can serve this purpose well in teacher education because they provide a site for deep inquiry about mathematics teaching and learning, and at the same time they preserve the inherent complexity of classroom life (Stein, et al., 2000; Silverman & Welty, 1996; Wasserman, 1994; Harrington & Garrison, 1992).

In order to answer the second research question, respondents were categorized according to the extent to which they used evidence from the cases to support their reflections on what they learned. This categorization resulted in 9 participants in the High evidence category, 11 in the Medium category, and 8 in the low category. We were interested to see whether there were any patterns to discern about what the participants in the three categories said they learned. We looked at the percentage of idea chunks in each of the four main coding categories (TM, M, S, C) out of the total number of idea chunks generated by each group. Table 1 summarizes these results.

Table 1
Percentage of idea chunks in each coding category for the High, Medium, and Low evidence groups.

Group	Teacher	Student	Mathematics	Value of Cases
High (99 ideas)	64%	15%	10%	11%
Medium (132 ideas)	80%	10%	4%	7%
Low (77 ideas)	85%	10%	-	5%

It is clear from the table that idea chunks about the teacher's role and how to teach were the most prevalent in all three groups and ideas about mathematical concepts were the least prevalent overall. This finding is consistent with past research that highlights the difficulty preservice teachers often have in focusing their attention on mathematical content (Mewborn, 1999). However, as shown in the table, there were also some discernable differences across the three groups with respect to the categories of ideas which they said they learned. The idea chunks of participants who more consistently grounded their reflections with evidence from the cases varied more across the categories than in the other two groups. The High group had more idea chunks related to student roles/student learning, their own math learning, and the overall value of studying cases than the other two groups. In fact, the Low evidence group has the least variation across categories. One possible explanation is that respondents in the High evidence group reflected more deeply

within and across cases and so the complexity of what could be learned from the cases is more evident in their reflections. Recent studies of pre-service teachers' reflection on teaching have found that the more reflective pre-service teachers the more they are able to articulate nuances about teaching, and the more they are able to focus on classroom experiences from multiple perspectives, particularly from the point of view of students and student learning (Ward & McCotter, 2004; Henningsen, in review). Thus participants who were less consistent in providing evidence are not necessarily learning less; rather, they may be less able to articulate what they think they are learning.

Ball, D. L. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education, 51*(3), 241-247.

Ball, D.L., and Cohen, D.K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond and G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice*, pp. 3-32. San Francisco: Jossey-Bass.

Barnett, C. (1998). Mathematics teaching cases as a catalyst for informed strategic inquiry. *Teaching and Teacher Education, 14*(1), 81-83.

Harrington, H. L. & Garrison, J. W. (1992). Cases as shared inquiry: A dialogical model of teacher preparation. American *Educational Research Journal, 29*(4), 715-735.

Henningsen, M.A. (in review). Elementary pre-service teachers' narrative cases of mathematics teaching as a lens for investigating learning from case-based experiences.

Henningsen, M. , Stein, M. K., Smith, M. S., & Silver, E. A. (2000). The use of cases in mathematics teacher education: Summary of the COMET invitational conference. Irving, TX: Exxon Education Foundation.

Kleinfeld, J. (1992). Learning to think like a teacher: The study of cases. In J. Shulman (Ed.), *Case methods in teacher education*, pp. 33-49. New York: Teachers College Press.

Mewborn, D. S. (1999). Reflective thinking among preservice elementary mathematics teachers. *Teaching and Teacher Education, 30*(3), 316-341.

Richert, A. E. (1991). Case methods in teacher education: Using cases to teach teacher reflection. In R. Tabachnick & K. Zeichner (Eds.), *Inquiry-oriented teacher education*, pp. 130-150. London: The Falmer Press.

Silverman, R., & Welty, W. (1996). Teaching without a net: Using cases in teacher education. In J. A. Colbert, P. Desberg, and K. Trimble, *The case for education: Contemporary approaches for using case methods*, pp. 159-171. London: Allyn and Bacon.Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Smith, M. S., Silver, E. A., Stein, M. K., Boston, M., Henningsen, M. A., & Hillen, A.F. (2005). Improving instruction in rational numbers and proportionality: Using cases for transforming mathematics teaching and learning, Volume 1. New York: Teachers College Press.

Smith, M. S., Silver, E. A., Stein, M. K., Henningsen, M. A., Boston, M., & Hughes, E.K. (2005). Improving instruction in algebra: Using cases for transforming mathematics teaching and learning, Volume 2. New York: Teachers College Press.

Smith, M. S. (2001). *Practice-based professional development for teachers of mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development.* New York: Teachers College Press.

Strauss, A. L. (1987). Qualitative analysis for social scientists. New York: Cambridge University Press.

Sykes, G., & Bird, T. (1992). Teacher education and the case idea. In G. Grant (Ed.), *Review of research in education, 18*, pp. 457-521. Washington, D.C.: American Educational Research Association.

Ward, J. R., & McCotter, S. S. (2004). Reflection as a visible outcome for preservice teachers. *Teaching and Teacher Education, 20*, 243-257.

Wasserman, S. (1994). Using cases to study teaching. *Phi Delta Kappan, April*, 602-611.