



Integrating Learning Mathematics and Teaching Mathematics in a Preservice Elementary Education Program in Greece

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Mathematics teaching in most Greek primary schools has the characteristics of direct teaching described by Confrey (1990) and is characterized by the belief that mathematics consists of a number of truths to be attained. The prevalence of this type of teaching implies that teachers' prior experiences as learners during their teaching practice in the schools is based on this model of teaching and learning. Considering mathematics teaching as "providing students with the opportunity and the stimulation to construct powerful mathematical ideas for themselves and to come to know their own power as mathematics thinkers and learners" (Simon & Schifter, 1991, p. 310), demands a radical change in prospective teachers' existing images of mathematics and teaching mathematics. Therefore, at Patras University we have attempted to restructure our mathematics courses for preservice teachers in a manner consistent with this philosophy. This article describes our efforts at such reform.

We see preservice teachers' development as a movement toward an awareness of the close interrelationship of the elements of the classical triad of subject-teacher-children in the teaching of mathematics. Cobb, Yackel, and Wood (1992) suggest that "students actively construct their mathematical ways of knowing as they are initiated into the taken-as-shared mathematical practices of wider society by the teacher" (p. 26). Helping preservice teachers become aware of what this statement means will help them learn to create environments in the classroom that foster children's mathematical development. Such awareness will also help them see mathematics as a human activity which can take place in their classrooms. They will begin to question what they teach, why they teach it, and how they approach it.

Reconstructing experience

According to Confrey (1990), students are continually constructing understandings of their experiences. Extend-

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ing this notion to prospective teachers causes teacher educators to ask how we can challenge their current views and help them question their prior experiences. This challenging and questioning may help prospective teachers reconstruct a different experience about teaching and learning mathematics.

We see two central foci for a preservice education program:

- the preservice teachers' mathematical development and
- the reconstruction of their teaching experience to emphasize children's actions.

The mathematical development of preservice teachers is characterized by a conception of mathematics as a human activity, as a process, as something more than a selection of facts and truths. Prospective teachers' mathematical empowerment is essential if we want the future teachers to evaluate children's current mathematical meanings and see ways they can build on those. As Cobb and Steffe (1983) describe "the actions of all teachers are guided, at least implicitly, by their understanding of their student's mathematical realities as well as by their own mathematical knowledge. The teacher's mathematical knowledge plays a crucial role in their decisions concerning what knowledge could be constructed by the students in the immediate future" (p. 85).

We also want the preservice teachers to move away from their egocentric view of how they learn, which seems to carry with it an overriding concern with what they are going to "teach." Instead, we want them to focus on their interactions with children and how these interactions can encourage children to work mathematically.

Our teacher education courses

The development of preservice teachers' mathematical knowledge and pedagogical knowledge must develop together rather than separately. Thus, although we offer separate content and methods courses, both courses emphasize mathematics content and pedagogy.

In the mathematics course, this integration is attempted in several different ways. One approach is to show the preservice teachers problems which involve children's

mathematical thinking. For example “A child gave the following answer to the question 29 times 4: 30 times 4 is 120; 1 times 4 is 4 so take 4 from 120 is 116. Try to analyze the mathematical properties that underlie this method and compare this with the formal algorithm of multiplication.” A similar approach is used to help them realize the conceptual difficulties that children face by experiencing similar difficulties for themselves. For example, it is common for preservice teachers to use the algorithms of the four operations without understanding the importance of the place value and of the structure of the number system. Considering these algorithms in other number systems reveals the complexity of the algorithms and the difficulties that children face. This is one of the ways we try to connect the mathematics that preservice teachers do with the mathematics of children. We also find that this approach can motivate preservice teachers to see the relevance of what they are doing in the course to their future profession. To get a sophisticated view of mathematics and regard it as a human activity, we encourage preservice teachers to solve and pose problems and to consider the use of mathematics in a variety of human activities. The historical evolution of mathematics together with the experience of mathematics as a way of communicating can also support this humanistic view.

In the methods course, preservice teachers learn about some teaching approaches by experiencing them as learners. For example, to see the role of open mathematical explorations in teaching, we ask preservice teachers to reflect on their own methods and thinking processes while solving an open problem. An example of such as problem is to place 18 bottles in a 6 by 4 cart so that each row and each column contains an even number of bottles. This type of reflection helps preservice teachers communicate their feelings of disappointment when they cannot make a start or their uncertainty about whether their solution is the only one. These experiences then help them consider what the role of the teacher might be in such a situation. We try to provide the preservice teachers with experiences similar to those we would like them to adopt in their teaching and a chance to reflect on and discuss these experiences.

Considering the teaching practice

The following example shows how preservice teachers might make a connection between learning and teaching

mathematics as they prepare for their first classroom teaching. The preservice teachers use a computer program which provides them the opportunity to mark a segment in a number of pieces and to explore the polygons they could create by moving the pieces. A number of problems are posed during this work not only by the teacher but also by the students. Problems such as “Is the equality of the sides enough to make a regular polygon?” and “Are there cases where the polygon cannot be constructed?” are typical. During this discussion the preservice teachers make hypotheses based on their preconceived notions about polygons and their properties, and they try to verify these properties using the program. This phase provides them with the opportunity to work on the polygons by themselves and communicate their ideas

At the next stage the prospective teachers watch a videotape of a group of children who are working on the same computer program.

This experience gives them the opportunity to observe and discuss children’s ideas about polygons. The prospective teachers also explore the interaction between the teacher and the children and how these interactions affect the children’s actions. This phase provides them the opportunity to see that children

use different methods than adults use and expect to see from the children.

During the next phase, the prospective teachers plan a lesson about polygons. While planning they discuss their ideas with us, and we encourage them to create environments where the children *do* mathematics instead of merely listen to mathematics. Their initial tendency is to find materials to show children some properties about polygons. We try to help them to reconsider this approach by encouraging them to hypothesize what the children are going to do and how they could plan their lesson to be responsive to children’s thinking. In these sessions we help the prospective teachers consider a number of ideas that have arisen in the methods course, and we help them reflect on their methods and children’s methods that emerged in the previous phases. In these discussions, they move from posing problems for the children to being problem solvers themselves. For example, in looking for ways to connect polygons with solids, they face the problem of finding the cross sections of a solid that can be made by a plane, which proves to be a rather difficult problem.

After the prospective teachers actually teach their lessons to children, we ask them to reflect on the experi-

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ence and to try to interpret the children's responses by forming models of children's ideas about polygons. We ask them to consider the interaction between their mathematics and children's mathematics. It is during the actual teaching and this retrospective phase that we could say that the preservice teachers actually learn children's mathematics.

This integration of learning mathematics and teaching mathematics in the different activities of a teacher education program can help future teachers to become researchers in their own classrooms. Such teachers will probably be constructivist teachers according to the definition of D'Ambrosio and Steffe (in press): "we will call teachers who study the mathematical constructions of students and who interact with students in a learning space whose design is based at least on a working knowledge of students' mathematics, constructivist teachers." To what extent this can happen is rather difficult to say, but the following comment from a student teacher shows a development of an awareness in this direction. "It is not only the mathematics we know but what the children do. In the course, I feel that we do more research on children's ideas and this is something essential in our teaching."

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