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Multimedia Environments in Mathematics Teacher Education: Preparing Regular and Special Educators for Inclusive Classrooms

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A multimedia CD-ROM program, *Mathematics Teaching and Learning in Inclusive Classrooms*, was produced to help preservice teachers learn mathematics teaching methods in the context of inclusive classrooms. The contents include text resources, video segments of experts and of classroom lessons, images of student work, an electronic notebook, and a tool to select content for visual presentations. Experiences using the program in undergraduate and graduate courses are reported. Overall, students liked using the CD-ROM and saw it as a valuable resource to gain exposure to expert opinions and inclusive classroom situations that would be otherwise inaccessible. A reflection on pedagogical issues surrounding the use of multimedia CD-ROMs in the teacher preparation context suggests that careful integration of high-quality resources such as this CD-ROM with "traditional" resources such as journal articles may offer the best experience for preservice students.

Faculty involved in teacher preparation programs take on many multidimensional goals. They must help preservice teachers master the art and science of teaching in general, become subject-matter experts in each content area (e.g., mathematics, science, language arts, and so on), and assist them in learning to differentiate instruction for increasingly diverse groups of students—including those with special educational needs. Because the number of courses preservice teachers take as well as the opportunity for exemplary field placements are limited, leveraging technology as much as possible to accomplish these goals is a priority.

Beginning teachers must develop solid understandings about mathematics and learn developmentally appropriate approaches for teaching mathematics to children with and without special educational needs. They are called to create reform-based classrooms (e.g., by teaching for understanding and developing children's mathematical power) as proposed by the National Council of Teachers of Mathematics (NCTM) (2000) and expected to meet national, state and/or district mathematics standards. In addition, because the Individuals with Disabilities Educational Act (IDEA) of 1997 now stresses meaningful access to the curriculum, children with special needs must have access to instruction that includes the same standards as their normally achieving peers (IDEA, 1997).

To accomplish these goals, Mercer, Jordan, and Miller (1996) suggested that general education teachers learn to consider both student and content factors when designing instructional strategies for diverse learners. In addition, special education teachers must know about mathematics curriculum and how to support children's conceptual development of ideas (Shriner, Dong-Il, Thurlow, & Ysseldyke, 1992). Instruction for students with disabilities must also go beyond the acquisition of knowledge of discrete topics to a comprehensive understanding of the discipline of mathematics (Woodward & Montague, 2002). Finally, for both general and special education students to be successful, teachers in each field must learn to collaborate using a variety of teaching approaches as well as technology (Sandholtz, Ringstaff, & Dwyer, 1997).

It was a desire to meet this combination of needs for students in two curriculum methods courses that provided the impetus for developing *Mathematics Teaching and Learning in Inclusive Classrooms*, a multimedia CD-ROM-based program. This resource was designed to help prepare regular and special education teachers include students with disabilities in regular education mathematics settings. The remainder of this article focuses on this CD-ROM application. First, we describe the contents of the CD-ROM program in detail. Next, we report on its initial use in one undergraduate and

one graduate course, as well as a more recent implementation. We end by addressing issues of pedagogy for both the K-12 inclusive classrooms and the university preservice teacher preparation classroom.

RATIONALE

Interactive CD-ROMs have proven to be attractive media in a wide variety of academic disciplines (e.g., Barron & Goldman, 1994), including special education (Fisher, Deshler, & Schumaker, 1999). Despite typically higher production costs compared to traditional delivery methods (e.g., leader-led sessions with text-only support), the pedagogical and learning benefits of interactive hypermedia are well recognized. A key benefit is the ability of the learner to explore the content according to personal preferences, and the opportunity to spend as much time as needed on any specific concept, topic, or problem. For teachers and faculty using these resources, the flexibility to support either an "active learning" approach (where students' explorations are almost entirely self-guided) or a "step-by-step learning" approach (whereby students are instructed to follow a predetermined path through the program) makes interactive CD-ROMs powerful resources for teaching (Kashihara, Kinshuk, Opperman, Rossen, & Simm, 2000).

The use of digitized video in CD-ROMs fulfills several different goals. In *Mathematics Teaching and Learning in Inclusive Classrooms* it serves two main purposes: (a) To present experts talking about their areas of specialty (e.g., inclusive classrooms; mathematics reform), and (b) To present real-world situations that would be inaccessible or impractical for the students. In our case, student teachers are facing what might be perceived as a triple challenge: learning to teach, learning to teach mathematics, and learning to teach mathematics in inclusive classrooms. Carefully selected video segments of actual teachers in practice can address all three levels at once, thus conveying complex information in a highly effective and efficient manner.

OVERVIEW OF THE CD-ROM PROGRAM

This CD-ROM program contains text content and resources, digitized still photographs, and edited video. The video segments are of two types: interviews with experts and episodes taken from mathematics lessons taught in kindergarten, second, combined third/fourth, and seventh grade classrooms. These grades were chosen so that the CD-ROMs can be used in university-level courses on early childhood math methods as well as in courses focused

on elementary (grades 3-4) or middle school (grade 7). Video footage of the lessons includes school-age children with and without disabilities (including children with high incidence disabilities, children with developmental disabilities as well as children who were low achieving, average, or gifted learners). Children were engaged in quantitative reasoning and problem-solving activities, and both the processes (their thinking) and products (drawn or written work) are available on the CD-ROMs.

Mathematics Teaching and Learning in Inclusive Classrooms is organized into three main menu items: "Views on Inclusion," "Mathematics Lessons in Inclusive Classrooms," and "Views on Mathematics Teaching and Learning." The total video time for each section varied according to the nature of the content: expert comments in the two "views" sections containing the expert comments were each approximately 10 minutes and each lesson was edited to approximately 20 minutes. Figure 1 shows a screen capture from the opening menu of the program. The "Views on Inclusion" section includes theoretical perspectives provided by special educators as well as segments of interviews with kindergarten and seventh-grade teachers and excerpts from lessons they taught—a total of 12 video segments. The commentary in this part of the program includes several perspectives on the meaning of inclusion, suggestions for differentiating instruction, and benefits and challenges inherent in the process of inclusion.

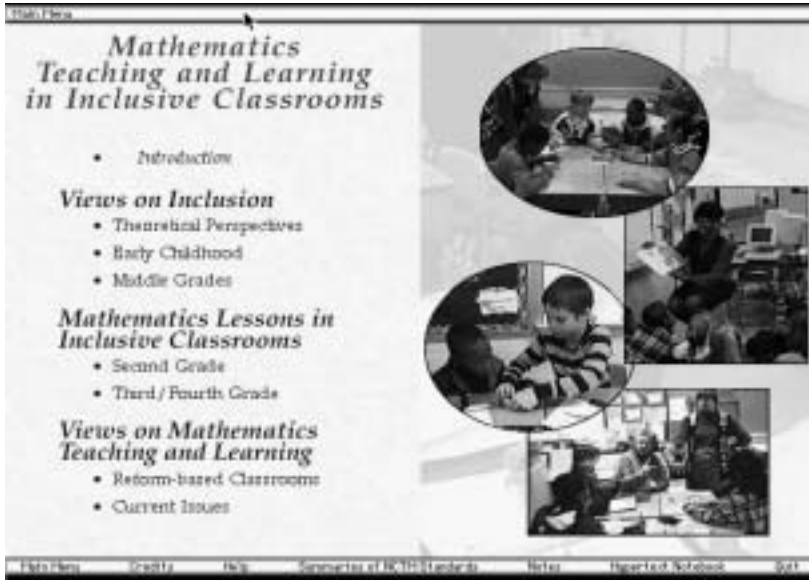

Figure 1. Screen shot of the first screen of the CD-ROM program *Mathematics Teaching and Learning in Inclusive Classrooms*

In the "Mathematics Lessons in Inclusive Classrooms" section, the focus is on one second grade and one third/fourth grade classrooms, including text descriptions and portions of the teachers' planning record, video of the respective lessons (7 segments for second grade, 13 segments for third/fourth grade), video of the teachers' reflections on the lessons (five segments from each grade), and video based comments from a mathematics educator (four for second grade) and from a educator with expertise in early childhood special education (three for third/fourth grade).

In the "Views on Mathematics Teaching and Learning" section, mathematics educators give their perspectives on important issues in mathematics education, such as national standards, mathematical tasks, the role of the teacher, and challenges inherent to teaching in a reform mathematics classroom—a total of nine video segments. We developed these materials to be resources for students' exploration, and envisioned that comments from the various experts as helping to inform and frame our beginning teachers' observations and analyses of the program's two extended investigations, described next.

To provide opportunity for in-depth investigations of learning and teaching mathematics, a second-grade lesson, contained on one of the CD-ROMs, and a third/fourth grade lesson, contained on the other, show extensive episodes of instruction and children's mathematical thinking. These classrooms were selected as representative of typical settings in public schools that preservice students will eventually encounter. In the second-grade classroom, the classroom teacher uses Merriam's (1996) book, *Twelve Ways to Get to Eleven*, as a context to help her class make real-life connections to addition and subtraction. The third/fourth-grade lesson is an introductory division lesson that incorporates group problem solving. For each of the two in-depth investigations, the classroom video data along with the children's written work, information on how the teachers formed the small groups and teacher commentary are available for students to explore. The third/fourth-grade classroom content also contains video in which the classroom teacher and the special education resource teacher planned the lesson.

Two tools available within the program are a notebook and an electronic presentation tool. Users can access the notebook to allow them to take notes while viewing the video episodes, thus allowing them to stay within the program without the hassle of switching to a word processor application. The presentation tool makes it possible to use a multimedia format to enhance the user's presentation of results from their investigations (Jonassen, Peck, & Wilson, 1999).

USE OF THE CD-ROM RESOURCE IN THE UNIVERSITY CLASSROOM

At the time in which this program was developed, Barron taught general education mathematics methods courses for undergraduates, and De La Paz taught a graduate course in mathematics instruction for students with special needs. Students in each of those methods courses explored the major issues previously identified by engaging in (a) within-class discussions, (b) small group and individual CD-ROM explorations in the university's computer lab, and (c) an electronic discussion group involving individuals in both courses (which is not discussed in this article).

Typical use of the CD-ROMs in classes began with an overview of the program and of the classroom episodes contained in the program (Ritchie & Baylor, 1997). After the overview,xý students working in small groups explored the video, graphic, and text resources contained in the program. The intent of this introductory session, which typically required one 50-minute class period, was to allow students to become familiar with the complexity of the issues addressed on the CD-ROMs. We posed questions and follow-up problems for students to consider, thus stimulating their inquiry (Kashihara et al., 2000). Students frequently worked in small groups and sometimes made class presentations.

Focused, in-class investigations and discussions of aspects of the mathematics lessons contained on the CD-ROMs followed these introductory activities. For each investigation, students had access to several resources to support their inquiry, including outside readings, the expert commentary in the "Views on Inclusion" and "Views on Mathematics Teaching and Learning" and the *Content Standards and Grade Level Expectations* from the NCTM. Problems, such as planning a follow-up lesson to one lesson on video, required students to revisit portions of the lesson to investigate different children's solutions strategies and to use other resources such as the standards. To complete the follow-up task, students worked in a computer laboratory setting (using the CD for approximately one hour followed by two or so hours of out-of-class work) independently or in small groups. The assignment required students to respond with a written description of the tasks or problems that they would pose in a subsequent lesson, the children's anticipated reasoning strategies, as well as the standards they were addressing and an assessment plan. Later in the term, students shared their findings and insights with the class in a 20-minute discussion.

To illustrate one of our expanded episodes of instruction in more depth, the classroom context for the combined third/fourth-grade class episode was as follows. This classroom was comprised of a regular classroom teacher, a

resource teacher with co-teaching responsibilities, and an interpreter. More than half of the 18 children had been identified as having special educational needs (which often happens in inclusive classrooms staffed by two teachers). The children's handicapping conditions included the following high incidence disabilities: mild mental retardation, learning disability, attention deficit disorder, emotional disturbance, as well as one low incidence disability—hearing impairment. The classroom teacher and the resource teacher co-planned and co-taught this lesson, as they typically did for each content area.

In keeping with the NCTM's recommendations that mathematics instruction should focus on problem solving and incorporate cooperative work (NCTM, 2000), the teachers in the combined third/fourth-grade class decided to introduce their class to division using problem-solving situations for the children to solve in small groups (Burns, 1991). Over the course of the lesson, teachers presented the class with three division problems in story format involving sharing (i.e., partitive division situations). One problem the teachers posed was as follows:

> Every day during one week, the guidance counselor met with a group of 4 students. Five groups went to her classroom during the week. The following Monday, she gave each group a box of stickers to share. There were 51 stickers in each box. Your mission is to figure out how to divide 51 stickers among 4 people so that each person gets the same number of stickers.

Manipulatives were available to use in solving the problem for the children who needed them.

In response to this problem, children in the first group counted out cubes, one by one, to each group member until they used 48 cubes, with three cubes remaining. The children in another one of the groups used a slightly more sophisticated strategy. They counted out two cubes for each child, then three for each child, then four for each, continuing in this manner until each child had 12. Three remained to give to a friend. Another group drew pictures to support their problem solving and did not use the cubes. Figure 2 shows the written solutions of all four groups as they appear in the CD-ROM program.

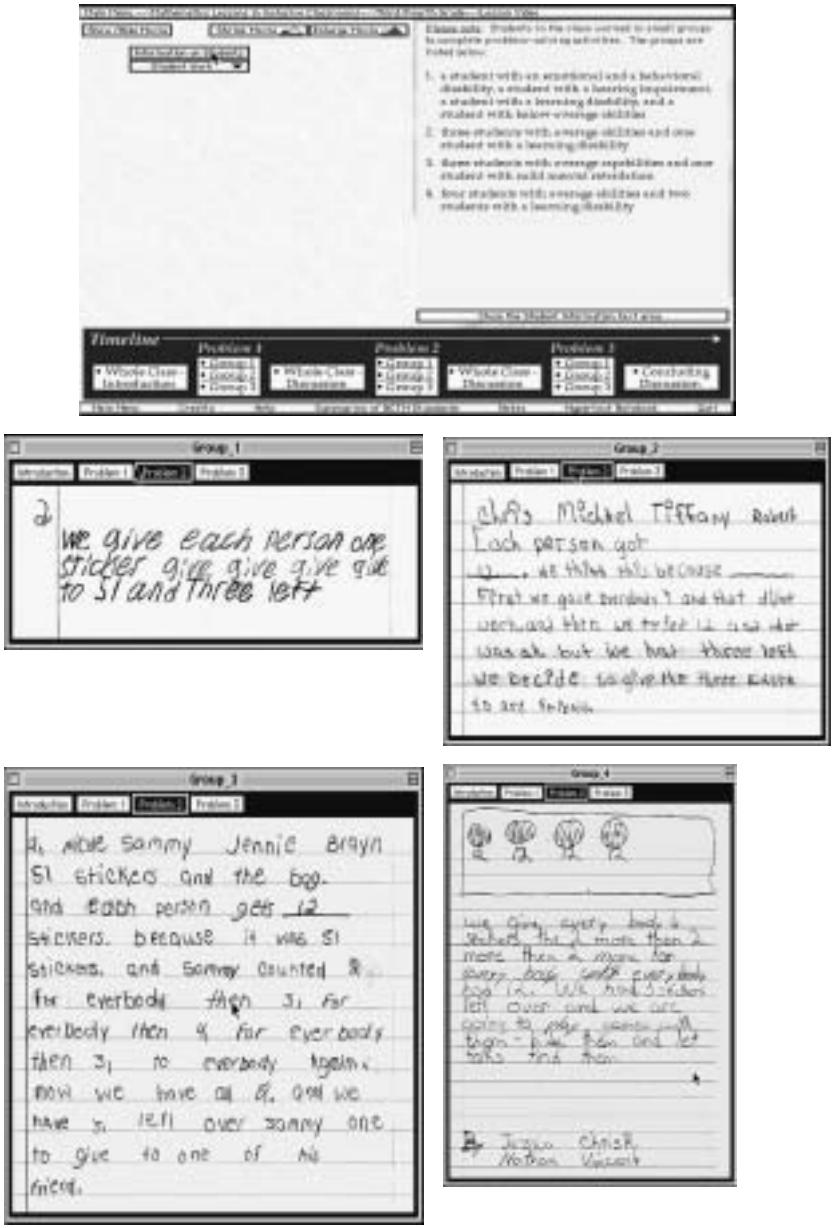

Figure 2. Screen shots of the introduction and samples of student work from third/fourth grade lesson with division problems

In the university classroom, this division lesson can anchor rich discussions about mathematics content and pedagogy. Specifically, the lesson allowed students to examine the various ways in which the third and fourth graders interpreted and solved the problems posed and the role of the teacher in guiding children's mathematical development. To illustrate, one focus we have used in both regular and special education methods classes is the children's mathematical reasoning. Examples of relevant questions posed to our students include: What different strategies and ways of thinking about grouping and division did the children use? In what ways did use of various representations support the children's mathematical reasoning? Anticipating children's mathematical thinking is central to effective planning for instruction (Rathmell, 1994), and the experience described here was intended to support students in considering a range of thinking levels as they began to develop plans for their own teaching. The ability to refer back to specific points in the video segments to support one's arguments, whether from the lessons or from the teacher interviews, is a major benefit of the CD-ROM program. After watching the lesson video, students' responses highlighted distinctions between partitive and measurement interpretations of division (Kennedy & Tipps, 2000). In addition, after examining the children's reasoning during the lesson on the CD-ROM, students had a better understanding of the children's need to use concrete and pictorial representations to solve problems before they were shown symbolic representations.

Students were also asked the following questions about pedagogy. If you had been the teacher, what aspects of their small-group work would you have emphasized in the follow-up discussions to advance the children's understanding of grouping and division? Do your ideas differ from how the teachers handled the discussions? Responses to these questions indicated that our students were able to see what could have been emphasized in the respective discussions on video. For example, in the third/fourth grade lesson, students cited the need to make connections between multiplication and division explicit. They believed the three problems posed to the children should have been presented in different lessons, and that the available manipulatives in the last problem were not useful (e.g., a 20 dollar bill should have been divided into smaller denominations of bills and coins).

The division lesson was also used as a context for exploring other pedagogical issues. Issues related to special education from this lesson in the CD-ROM included the role of an interpreter and the teachers' rationale for deciding how to form each small group. For example, students learned that sign language interpreters, unless specifically requested to do so, do not routinely translate between a hearing impaired child and his or her classmates in

a small group setting (rather, they translate what the teacher tells the class and what the child who is hearing impaired tells the teacher).

We asked students to consider teaching strategies that they thought were effective in supporting the learning of the various special needs students in the class. To answer this question, students were asked to refer to an article they had read on co-teaching (Vaughn, Schumm, & Arguelles, 1997). In addition, they examined video segments in the CD-ROMs, which showed the regular teacher and the special education teacher making decisions about who would work in each small group in the planning session that occurred before the lesson. The special education teacher made suggestions to the regular education teacher based on her understanding of each child's strengths and the impact of his or her disability. For example, one child with a hearing impairment was to be the recorder for the first group "because his writing skills are good" and thus would likely contribute meaningfully to the group processes. Further, a child identified as mildly mentally retarded was to be placed in the second group with children "who have higher-level thinking skills" because "he has good communication skills and loves to figure things out." After reading the article, watching the planning session and the actual lesson in the CD-ROM videos, students were able to suggest alternate arrangements for maximizing the special education teacher's expertise. Other discussions focused on implications for teaching, such as how teaching standards corresponded with segments of the lesson, and how experts in special education and mathematics education viewed the instruction.

STUDENT FEEDBACK

Use of the CD-ROMs in both the special and general education mathematics methods courses has been perceived as successful by the instructors. One of the objectives for the development of the program was to provide preservice teachers the opportunity to see by way of video, some of the challenges they will encounter in their future classroom environments. By presenting them with video from an authentic setting (i.e., the classroom situations were not specially staged for the CD-ROM program), the goal of helping students understand the theoretical and practical issues arising in these contexts would be met.

One way to find out if these ambitious goals are being fulfilled may be to ask our students1. As expected, the CD-ROM program is not an ideal tool for all students, though it is proving to be a very helpful tool for most. Written comments from students in the initial general and special education classes appeared to support the belief that these interactive video-based

experiences can serve as a starting context in preparing beginning teachers for the complexities of teaching mathematics in inclusive classrooms. An important outcome was that many of the students valued the idea of developing collaborative relationships in helping students learn mathematics. As such, students frequently mentioned the need for collaboration in planning instruction. To quote one undergraduate, "Students with disabilities can find success in the regular classroom. I believe that collaboration between regular and special education professionals makes this possible." In addition, we found evidence that students in the special education mathematics classes gained a greater appreciation for the complexities inherent to teaching mathematics. One student reported,

> The experience of watching the videos in class was a beneficial one. It gave me a chance to observe a lesson and a class and critically analyze the teaching. This was helpful because it gave me an opportunity to think about what we had been discussing in class with regard to what is important in teaching math concepts.

At the end of a recent term, De La Paz asked students to compare how they were exposed to teaching students with special needs to teaching students who were English learners (i.e., to contrast using the CD-ROM, vs. additional reading assignments, class discussion, and assignments for both). They were also asked what was most helpful, and to provide a rationale for their comments. Only one student (out of 23) expressed a less than favorable view on the use of the CD-ROM program, stating that "I didn't feel the video/CD-ROM was that helpful because we didn't know the students well enough to understand their learning styles."

In contrast, the vast majority of students expressed a range of favorable opinions, ranging from very general, such as "I liked the CD-ROM stuff, it was a good tool," to more specific, such as "The CD-ROM was more helpful than the articles. The fact that it was visual and auditory helped to hold the interest. Class discussions provided insight into different viewpoints and the assignments helped crystallize things in the mind." Other students liked the interview segments either because of the opportunity to see and listen to experts in the area (e.g., "I liked watching the CD-ROM because I found the commentary very helpful and insightful. It is very helpful for me to be able to glean knowledge from experienced educators") or because of the opportunity to see a context of practice with which they need to become more familiar (e.g., "I found it helpful to see the video's commentary clips addressing students with special needs. Hearing the info from these people was good exposure").

A few students remarked on the benefits of having all the resources assembled in the CD-ROM. For example, one student wrote, "I feel that the CD-ROM was most helpful because it is one thing to read about a topic but another to actually *see* [emphasis in original] how principles apply." On a similar vein, another student's comment captured the reaction to one of the limitations (direct observation) that the CD-ROM is designed to address: "I thought the CD-ROM assignment was the most useful because it was the most concrete. It is easy to talk and read about special needs students but it doesn't compare to seeing them in action. An even better way would be to be able to observe or teach such students directly (but of course I don't know how feasible this would be)."

Finally, some students reflected on the experience to the level of suggesting possible improvements to the program. One of them wrote: "The CD-ROM was somewhat helpful. It would have been better if we had text to read on the CD-ROM to match the interviews." Adding transcripts of all video segments would have been, indeed, a nice feature but one that would have consumed too much time and resources. Another student's comment centered on the type of classroom shown on the video segments: "Would have liked to see a *live* [emphasis in original] interaction of ESL class and teacher (in contrast to only seeing that for special education)."

This last comment points to further enhancements that could be added in the future. When broadband connectivity becomes widespread, it may be possible to establish a school/university collaboration where student teachers would be able to observe classrooms through streamed video or even 2-way videoconferencing (Kinnear, McWilliams, & Caul, 2002; Sharpe, Hu, & Crawford, 2003). The latter would also make it possible to create opportunities for conversation and discussion between the student teachers at the university and the teachers in the inclusive classrooms (Falconer ÿ & Lignugaris-Kraft, 2002).

Finally, whether in a fixed (desktop computers) or mobile (laptop computers) lab environment, when multiple users are trying to listen to the CD-ROM audio the ensuing noise can be detrimental to all, particularly if students are being asked to work in pairs or small groups and the computers have only one plug for earphones. While there is little to do in a fixed lab environment, mobile computers allow students to move further away from each other so as to minimize the interference with each other's sound space.

COMMENTS ON PEDAGOGY

As Herrington and Standen (2000) noted, "Little credence is now given to learning theories that propose that learning is no more than the transmission of a body of knowledge from teacher to student" (p. 195). At the other extreme, few would argue that exposure to information in a multimedia format is, by itself, an ideal learning scenario. Given the multidimensional challenges faced in teacher preparation, integrating technology-based resources such as the *Mathematics Teaching and Learning in Inclusive Classrooms* CD-ROMs with more traditional class activities such as reading additional articles before coming to class may be a better strategy. As rich as these CD-ROMs are in information, students are more likely to benefit from them if they have first established some background knowledge on topics such as (a) introducing the concept of division (Burns 1991), (b) "constructivism" as more than one instructional ideology (Mercer, Jordan, & Miller 1996), (c) using a pyramid planning structure to differentiate lesson objectives that match the needs of different types of learners in their classrooms (Schumm, Vaughn, & Leavell, 1994) and (d) innovative coteaching models (Vaughn et al., 1997).

Our experience suggests that this combination of resources best allows prospective teachers to explore complex teaching situations and offer their own solutions to questions raised by observation of authentic classroom settings. For prospective teachers, the opportunity to observe authentic classrooms environments where coteaching in inclusive settings is modeled, along with innovative mathematics instruction, is a unique contribution of the CD-ROM program described here. Even with the recognized limitations of the medium (e.g., time and cost to prepare, only a few lessons are videotaped, only a few teachers and experts interviewed in depth), students reported gaining solid benefits from work with the program since in-person visits to similar classrooms are difficult or impossible to arrange on a regular basis.

CONCLUDING COMMENTS

As noted at the start of this article, helping preservice students overcome their apprehension about learning to teach in general, learning to teach mathematics, and doing so in inclusive classrooms is a challenge that is best addressed through a combination of teaching strategies and resources. The

successful inclusion of diverse learners in mainstream mathematics classrooms remains challenging. Gaining a rich understanding of ways to stimulate children's mathematical reasoning is an essential element for all teachers. This experience suggests that combining teaching strategies (e.g., coteaching, inclass discussions) and technology supports (e.g., CD-ROMs) is a valuable way to achieve those goals.

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Note

While a follow-up study in which we examined the impact of the CD-ROMs on students' actual teaching was not possible, work by others in this area has found multimedia to have a lasting impact on preservice teachers (Lampert & Ball, 1998).