Using an Interactive Multimedia Professional Development Tool to Develop a Teacher's Understanding of Mathematics Teaching

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Abstract

This qualitative case study investigates how one teacher used an interactive multimedia professional development program (*Understanding Teaching --UT*) to help learn and apply the *Professional Standards for Teaching Mathematics* published by the National Council of Teachers of Mathematics (NCTM). This teacher spent 14 hours using *UT* over the course of one school year. Pre/post-assessment data indicated that she improved in her ability to correctly identify the NCTM *Professional Standards for Teaching Mathematics* and in her attentiveness to mathematical discourse in the videos. Observation and interview data indicated that she incorporated new questioning strategies into her teaching practice and began trying more challenging mathematics with her students. These findings are discussed in difficulties that face teachers who attempt the kinds of professional and curricular change that many educational reformers are advocating.

Professional development for practicing teachers is a topic demanding increasing attention in forums on critical issues facing education (Tally, 1995). The publication of the *Curriculum and Evaluation Standards for School Mathematics* in 1989, the *Professional Standards for Teaching Mathematics* in 1991, and the *Assessment Standards for School Mathematics* in 1995 by the National Council of Teachers of Mathematics (NCTM) created the basis for a program of professional development "unparalleled in the history of the teaching of school mathematics" (Aichele, 1994, p. vii). The *Professional Standards for Teaching Mathematics* is a unique document because it focuses on changing the way that mathematics is taught. These documents make a clear connection between professional development and curricular change (Castle & Aichele, 1994).

Five years ago, David Cohen (1991) told the story of Mrs. O, a dedicated teacher who believed that the NCTM *Standards* had made a change in her classroom. Her work had moved from teaching calculational mathematics (Thompson et al., 1994) in a traditional way to using "math manipulatives" and new activities to develop her students' mathematical understanding. But what she did not realize is that the revolution wasn't really finished. In her new approach the key to teaching math was to get children doing the right sorts of activities using appropriate materials. But little attention was given to the importance of students explaining mathematical ideas, i.e. engaging in mathematical discourse. Mrs. O. was not really teaching the conceptual math called for in the NCTM *Standards*, a math that focuses students' attention "toward a rich conception of situations, ideas, and relationships among ideas" (Thompson et al. 1994, p. 86).

One of the obstacles for Mrs. O. in implementing the *Standards* was the dearth of effective professional development resources available to her. The instructional changes that reformers are calling for are great; teachers must learn how to teach in new ways while at the same time learning how to think in new mathematical ways. Just what would it take to help Mrs. O. learn more about mathematics teaching?

This paper tells the story of Mrs. N., another energetic and dedicated teacher who, like Mrs. O., was engaged in teaching "manipulative mathematics" with her students. The goal of this research study was to investigate how an interactive multimedia system might be used as a professional development tool to help a practicing teacher move her vision of teaching and

learning toward the conceptual mathematics described in the NCTM's *Professional Teaching Standards*.

A Summary of Interactive Multimedia Use in Mathematics Education

Previous studies have shown the effectiveness of using interactive multimedia technology in the field of mathematics education. A meta-analysis of interactive videodisc (IVD) training in military, industrial, and higher education showed a significant improvement in achievement provided by IVD instruction compared to more conventional and less interactive forms of instruction (Fletcher's, 1989). Goldman (1993) and her colleagues found that when video illustrations are used in a math methods class with pre-service teachers to demonstrate teaching techniques, these techniques are incorporated into their field experiences. She discussed the potential of this new technology to move teacher education from lecture to problem-solving and analysis of rich case histories. Van Galen (1993) found that video vignettes of classroom situations can facilitate reflection among in-service teachers in mathematics when used as part of a course in The Netherlands led by a teacher educator; he was very wary of any attempts to introduce interactive multimedia as a stand-alone tutorial outside of a course structure. Bitter & Hatfield (1993) found that preservice students in a mathematics methods course who used an interactive multimedia system showed more appreciation for using manipulatives, demonstrated better observational power, and reported gaining a better sense of the elementary classroom. Clark (1995) evaluated an updated version of that same interactive multimedia program and found that preservice teachers were better able to recognize, identify, and explain more of the NCTM's Professional Teaching Standards than preservice teachers who used the NCTM's text publication. Her report recommended using the same *Understanding Teaching* program as a professional development seminar with in-service teachers in the field. Bitter and Pryor's (1995) pilot evaluation of an updated version of this program with a group of in-service teachers indicated that it was perceived by potential users as an appropriate means of teaching the Standards. More recently, Lambdin, Duffy, & Moore (1997) found that preservice teachers in a mathematics methods course who used an interactive multimedia product (The Strategic Teaching Framework--STF) modeled their own teaching on the examples provided in STF as well as using the videos as a basis for their own reflections. Thus research suggests that interactive multimedia may provide an effective means for doing professional development with teachers.

***Understanding Teaching,* an interactive multimedia professional development tool**

Understanding Teaching: Implementing the NCTM Professional Standards for Teaching Mathematics (*UT*) is an interactive multimedia program on CD-ROM designed as a professional development tool to help teachers learn and implement the NCTM Professional Standards for Teaching Mathematics. Developed by Technology Based Learning and Research (TBLR) at Arizona State University, this set of four CD-ROM disks provides the user with guided observation experiences in classrooms to demonstrate the NCTM *Professional Standards for Teaching Mathematics.* The videotaped lessons teach concepts of geometry and numeration.

UT is composed of four learning modules: Professional Development, Teachable Moments, Application, and Assessment. In the Professional Development module, users view 46 full-motion video vignettes of approximately two to five minutes in length demonstrating each aspect of the six NCTM Professional Standards for Teaching Mathematics. With the Teachable Moments module, users view 17 different lessons, each incorporating several of the NCTM *Professional Standards for Teaching Mathematics*. Users get a chance to practice identifying the NCTM Professional Standards for Teaching Mathematics as they naturally occur in a classroom. With the Applications module, users apply their knowledge by creating a lesson plan based on the NCTM Professional Standards for Teaching Mathematics. With the Assessment module, users view a video vignette, select all of the NCTM Professional Standards for Teaching Mathematics that are shown in that vignette, and write their rationales for each selection. After they have made their selections and written their rationales, the users may view the Teaching Standards selections of different experts and others at their own school who were using the same

computer. There are eight such videos in the Assessment module, though for purposes of this study Mrs. N. viewed only two.

This product was field tested in its development and a prototype was used in a previous study (Clark, 1995). *UT* was selected as a Silver Winner as part of the 1995 NewMedia Invision Awards program. But this study is the first school-based trial of this multimedia professional development tool. The program requires a Windows compatible Multimedia Personal Computer, level 2 (MPC-2) machine or higher. A Macintosh version has since been developed and tested (Pryor, 1996).

Mrs. N. and her professional setting

The school in this study was located in a rural area that (like Mrs. O.'s school) is being consumed by the increasing suburban sprawl of a nearby metropolis. The ethnic composition of the school was sixty percent Anglo, forty percent Hispanic. Over fifty percent of the students qualify for free and reduced lunches.

Mrs. "N.", a Caucasian, is a 15 year veteran of teaching who works with two classes of kindergartners every day. She is considerate of her students and brings considerable energy to the classroom. Hers is the kind of classroom one would wish for one's own kindergarten-aged child: orderly, friendly, active; a community of learners.

She had access to an Intel-based multimedia computer in her classroom as a part of the district's efforts to upgrade their technology. Her principal arranged for their participation in this research project along with other teachers in his school. He gave them professional development credit for the time they spent using *UT*, and hoped that they would then use *UT* to teach others on the staff.

Method

A qualitative case study approach was chosen for this investigation. Researchers in mathematics teaching and learning find case studies useful in understanding the complexities of practice (Lampert, 1986; Fennema, Franke, Carpenter, & Carey, 1993). Stake (1995) and others (Shulman, 1987) have noted that case studies provide particularly rich illustrations. Case study research has been critiqued for its limited scale (Bogden & Biklen, 1982), but others (Erickson, 1986; Stake, 1995; Peshkin, 1993) suggest that the depth of case study inquiry provides unique insights that are useful in other contexts.

Data were collected around three major issues in the study: How did Mrs. N's understanding of the *Professional Standards for Teaching Mathematics* change after using *UT*, how did Mrs. N. use *UT*, and how did Mrs. N's teaching change after this experience?

An instrument for assessing Mrs. N.'s understanding of the NCTM *Professional Standards for Teaching Mathematics* before and after using UT was designed. She viewed two videos from the Assessment module, selected from a form which of the 46 aspects of the Professional Teaching Standards she saw in that lesson, and wrote her rationales for each aspect selected. Her pre- and post-assessment responses were compared to each other, and her post-assessment responses were compared to the responses of experts provided in the Assessment module of *UT*.

Mrs. N. was observed as she used *UT* with a colleague at her site. Formal observations of their use of *UT* were audiotaped and transcribed. She was also interviewed, both individually and in focus groups, about how she used *UT*. She also kept a self-report log chronicling her use of *UT*.

Mrs. N. was also observed as she taught mathematics lessons in her classroom. Two lessons were observed and scripted, one near the beginning of her use of *UT* and one in the spring, after her use of *UT*. She was also interviewed, both individually and in focus groups, about what she

thought she learned from using *UT* and how she planned to incorporate the NCTM *Professional Standards for Teaching Mathematics* into her own classroom. Various teaching materials that she used in lessons with her students were collected, as well as the district's professional development plan and curriculum documents.

The primary method of analysis used in the study was direct interpretation (Stake, 1995). Interpretive memos were written after observations, after interviews, after transcribing the interviews, and after reading documents. In this way a growing list of assertions about the case was kept. These assertions were made and then checked against other data. Evidence was sought to confirm or disconfirm assertions and further elaborate on each assertion as new data was collected. Participants were asked to confirm assertions in member checks.

Asking the Why Questions: The Case of Mrs. N.

Mrs. N.'s classroom has changed this year. She knows the *Standards* better as a result of using *UT*, and she is beginning to implement *Standards*-based mathematics in two ways: she is using some new questioning strategies that are enriching the mathematical discourse in her classroom, and she has introduced more challenging content into her mathematical curriculum. She also used *UT* as a source for new mathematics activities, but was frustrated that *UT* was not designed to be used this way.

Using *UT*

Mrs. N. reported using *UT* for 14 hours total over a period from October to April. Nine hours of that time was split equally between learning the *Professional Standards for Teaching Mathematics* in the Professional Development module and seeing those Standards applied in everyday lessons in the Teachable Moments module. She spent one hour taking the pretest, and two hours each in the Assessment and Application modules. The investigator observed Mrs. N. using *UT* for 2.5 hours. She used *UT* primarily with two different partners; she was not able to work with the same partner all the time because of scheduling difficulties. The length of a session varied from 45 minutes to 2 hours, but most sessions using *UT* lasted for 1 hour.

In observing Mrs. N. using the *UT* program, one of the things that consistently preoccupied her was determining the mathematical task for the students in each segment shown. Determining the task proved to be very difficult, not only for her but also for other teachers in the group, according to their account in the interim focus group interview. The STRATEGIES button was a feature in the Teachable Moments module that provided additional context, but they never found it on their own. Once they were shown that feature it still did not answer all of their questions.

Just what the students were being asked to do in each lesson interested Mrs. N. a great deal more than it did the program designers. In watching the videos, she expected to learn some specific new activities to try with her students, whereas the designers thought that what she would be learning was a set of generic teaching techniques. When Mrs. N. visits another classroom vicariously through the video camera, she does not look first for exemplars of correct technique, but for a set of activities that she can do successfully with her students. This observation fits with Thompson et al.'s (1994) recommendation of providing a "repository of rich problems" (p. 90) for teachers to begin using with their students as a critical element in helping teachers begin to move toward conceptual mathematics.

Improved Understanding of the *Professional Standards for Teaching Mathematics*

In the pre-/post-assessment analysis there was further evidence that Mrs. N.'s understanding had changed through her experience with *UT*. After using *UT*, she selected more of the Standards as the experts cited in the Assessment module. More importantly, Mrs. N.'s rationales more closely resembled that of the experts. For example, in the pre-assessment she viewed the teacher's role as asking stimulating questions, listening to their mathematical responses, and guiding students through the activity. But in the post-assessment she saw new elements of the teacher's role. The teacher is to extend the student's thinking and to ask students to rethink their answers. Before using *UT* she said that the teacher's role in discourse was limited to requiring

the students to discuss with a partner. After *UT* she mentions new roles that align with notions of discourse: questions stimulate thinking, the teacher responds to what the students say, and most importantly, that the students clarified their ideas orally. This corresponds with what the experts saw in this segment. One of their stated rationales for Standard 2.1 in the same video is that "The task engages some students and had them compare answers and discuss responses." Their answers share Mrs. N.'s emphasis on the importance of the oral clarification of the student's mathematical ideas.

Changes in Teaching Practice

Using *UT* changed Mrs. N.'s teaching practice in two ways. She began using new questioning strategies, and she began doing more challenging mathematics with her students.

New questioning strategies. In November interview she noted that the teachers in the *UT* video "don't ask why questions as much as how, and why do you think it is this way?" Mrs. N. explained how her graphing lessons were changing.

> When you first saw me graph apples *I* did everything. Today I had them put the cookies–they were graphing who likes cookies [for snack], who likes doughnuts–*they* would put the markers on the graph. Then I would ask the class, "Should it be there? Should it not? Did they put it in the right place?" And then I would say to them, "How do you know?" And they would start discussing. "I think it's this," and "I think it's that," and "I don't think it's fair." Then they had to show us. Well look! They started talking and interacting. And I'm kind of out of the picture. Isn't that what I want? I want to be out of the picture. . . . You enjoy them discussing it. *They're* discussing it and then talking back to each other about the way the picture is what it is.

Mrs. N. is not a teacher who is new to the idea of active discussion in her classroom. But what seemed to be new is the idea of active discussion in the midst of mathematics. Mrs. N. has used the *Mathematics Their Way* (*MTW*) program for a number of years in her classroom. The assumption of that program are not fully aligned with the NCTM *Standards* and notions of conceptual mathematics (Cohen, 1991). The "manipulative mathematics" of *MTW* is still focused on learning the procedures of mathematics, but by using new materials and new methods to accomplish this. The critical new element in *MTW* is new mathematical activities, not new mathematical discourse. This same belief was reflected in Mrs. N.'s practice, but now it appears that is changing after using *UT*.

During the final interview conducted in May, Mrs. N. provided an example from her classroom of how her questioning strategies had changed. She looked across the room, over at the area where the class gathers everyday for a *MTW* activity called calendar. There the students note the day of the week, the weather, count up the number of days of school so far, etc. They also try to detect a pattern in the shapes that Mrs. N. uses to mark the days of the month.

> Like on calendar, it is always a pattern [she points at the calendar hung up on her wall]. See the pattern? Yellow, maroon, pink. Yellow, maroon, pink. [Indicating the pattern of the color of letters for each numbered day of the month, i.e., the first is yellow, the second is maroon, the third is pink.] I've always done this: I say to my students, what color comes next. . . . But now I say to the student who answers, whether it's wrong or correct, why? How do you know that that is true? Why do you say that? How do you know yellow is going to be next? Then they have to tell me why. They have to give me the reason. . . . They have to present it out loud. So they have to justify. . . . But they are doing it. They are successful . . . I never [used to] ask those questions. I didn't think of it . . . but it makes a big difference.

Note that the *MTW* activity itself is no different here, but the discourse surrounding the activity is what has changed in this example. Through her interactions with the investigator and *UT*, Mrs. N. is beginning to involve her students in more mathematical discussions.

In April at the conclusion of the study a final focus group interview was conducted. This gathering provided closure to the project as well as addressing concerns about the brevity of the *UT* videos that the teachers in the project had expressed. The participants were shown a 45

minute videotape of a teacher doing one lesson that particularly focused on demonstrating mathematical discourse. This video was made as part of the Math Discourse Project (MDP), an effort funded by the National Science Foundation aimed at better showing mathematical discourse in actual classroom lessons. After watching this video of a lesson taught by a multi-age classroom (grades 3-5) teacher, Mrs. N. had this to say:

> You know what she does a lot of, and its like a light going on for me. She doesn't give them paper and give them an assignment and tell them to do this. Instead she gives them a task that has a problem, and she allows the students to solve it. It sounds like she initially allows them to solve it as a group, or they discuss it as a group. She allows them to defend their reasoning, and to show her how they arrived at their conclusion. And then sometimes she allows them to go back, with their group or sometimes individually, and work it out on their own . . . I thought it was much better than the previous *UT*.

For Mrs. N. this video clip was much better than *UT* because it focused on improving mathematical discourse in the classroom. As she watched the students in the video defend their reasoning, she realized more clearly the value of having students make their thinking public through discussion. At the end of the study Mrs. N. states very clearly that she has learned new questioning strategies from *UT*. "I never asked those kinds of questions before. I didn't think of it. . . . It means that for every mathematics lesson I am doing I am using a different strategy." The key to these new questioning strategies is that they allow her to "see my student's thinking." She saw more of those new strategies in *UT* and the MDP video, and she began to encourage her students to defend and explain their responses in the classroom.

More challenging mathematics. There is a second and related way that Mrs. N. says that her teaching changed: she has begun teaching more challenging mathematics to her kindergartners. This change emerged in part from the "why questions" conversation of September, but more from a discussion in November during one of the sessions when Mrs. N. and a colleague were using *UT* with the investigator serving as an observer. They were watching an observation from the Teachable Moments module. Mrs. N.'s initial concern was whether or not second graders should even be doing division since that content is usually reserved (in her mind) for third grade. Next she wonders if they really understand the division. The breakthrough in her own understanding came when she sees how easily division can be demonstrated using the manipulative materials. In the video, the student initially struggles with the task, but is successful with the teacher's help on the second try.

What so impressed Mrs. N. in the video is how higher level mathematical operations like division could be brought down to a primary level through the use of manipulatives. She had used manipulatives in her own classroom with her assigned content, but had not thought about how manipulatives might provide a window to more challenging content. Mrs. N. was taken with the idea of exploring more challenging mathematics with her students despite her concerns that she might be intruding into what the first-grade teachers cover in mathematics.

So Mrs. N. began teaching addition with regrouping to her kindergarten students in the context of a flash card racing game that they play. The students can not only add the two numbers when they are shown on the board, but they can also count the cards. Mrs. N. is accustomed to integrating mathematics activities with reading activities. But now she is trying more challenging mathematics when she integrates her lessons. She and her kindergarten students were adding numbers like 38 and 14. They did this together on the board, and for some of her students it is an exercise in counting (not regrouping), but in the context of the flash card game it is something that her whole class can participate in doing.

Providing engaging and challenging activities is not new to Mrs. N. But what was new was that these activities could include mathematical content that was "above grade level" such as the example from *UT* of doing division with second-grade students. In the final interview, when asked to describe how her teaching had changed as a result of using *UT*, Mrs. N. gave yet another example from that day's activities: teaching fractions to kindergartners during a pizza party. That is not in most kindergarten mathematics curricula, and it is probably not an end result that

the creators of *UT* ever anticipated. But Mrs. N. is now thinking about mathematics differently in her classroom. In a discussion after school she stated that since using *UT* she now does more mathematics, and that she now believes that she "can get more out of her students than I used to." Mrs. N. now has higher expectations for her students in mathematics, and higher expectations for herself as a facilitator of mathematical discourse. These higher expectations came through her interactions with the investigator and through her use of *UT*.

Discussion: *UT* as a Facilitator of Changed Practice

Mrs. N. knows the *Standards* better after using *UT*. Her results resemble those of Clark's (1995) work with pre-service teachers; after using this interactive multimedia professional development tool, Mrs. N. is better at identifying the *Professional Standards for Teaching Mathematics* and at giving an accurate rationale for her selection. "One thing that I did notice when I took the post-assessment is that I could more readily come up with Standards. I felt much more comfortable answering the questions . . . Some I could tell that definitely those Standards were not evident. And others I would say, 'Yes, I think that they were.' I was pretty confident that they were." The analysis of her pre- and post-assessment responses also reveals an eye that is sharper at looking for mathematical discourse.

Most notably, her teaching practice has changed. She is employing new questioning strategies and has developed higher expectations for her students' mathematical endeavors through both her conversations with the investigator and by finding examples of discourse and mathematical activities in *UT*.

In her use of *UT* she, along with her partners, consistently saw the videos as a source of new teaching activities that they could try with their students and not as a demonstration of superior teaching techniques. To this end they were frustrated because the designers of *UT* did not foresee that the teachers would be using their product in this way.

Does the case of Mrs. N. show that interactive multimedia can provide the kind of professional development resource that can change teacher thinking and tilt their practice toward that of conceptual mathematics? The results suggest that *Understanding Teaching* provided the resources that helped Mrs. N. learn how to change her practice. The change in this case happened through interaction with the researcher (cast in the role of a teacher educator) as well as interaction with a larger group of teachers, much as van Galen et al. (1993) reported earlier.

One could argue that Mrs. N. is certainly better off than most teachers for having seen examples of the *Professional Standards for Teaching Mathematics*. She is better off than Cohen's (1991) Mrs. O., who mistakenly believed she was teaching in accord with the *Standards*, while a closer examination of her case revealed that she was really only practicing "manipulative mathematics" and not the conceptual mathematics of the NCTM *Standards*. Mrs. N. is at least beginning to engage in the newer forms of mathematical discourse that are critical to the NCTM *Standards*, and part of what helped her do this is her chance to vicariously visit the practice of other teachers through *UT*.

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