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ABSTRACT

Qualitative methods were used to study: (1) the effect of engaging in a mathematics teaching experience in an alternative high school program, the Transcend program, on preservice teachers' beliefs; and (2) the effects of a guided preservice teaching experience on at-risk learners' beliefs, self-concepts, and mathematical development. Five secondary preservice mathematics teachers and five at-risk learners were the subjects of the study. Researchers used observations, videotaped classes, interviews, and a mathematics assessment to gather information about the effects of the alternative mathematics program. Case studies of three preservice teachers and two learners are presented to illustrate their development and interactions. There were changes in the self-concepts of the teachers, their perceptions of at-risk learners, and their instructional practices, although many of their beliefs remained unchanged. Students experienced learning gains, especially with regard to increased mathematical self-concept. Transcend appears to have provided both teachers and learners with a unique environment to enhance mathematics teaching and learning. (Contains 27 references.) (SLD)

Exploring Mathematics: Possibilities For Learning In An Alternative High School Setting

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INTRODUCTION

Equity in the mathematics classroom may be defined in three ways: (1) equal opportunity to learn mathematics; (2) equal educational treatment; and (3) equal educational outcomes (Fennema and Meyer, 1989). The latter interpretation moves beyond the traditional definition of equity as equal opportunity to one that supports equal achievement and future participation in mathematics and ensures that students have a real chance to become engaged in and to learn from the academic core that they encounter (Secada, 1989, p. 40).

Resnick (1995) identifies the two challenges facing American education today as raising overall achievement levels and making opportunities for achievement more equitable. The mathematics education reforms envisioned by NCTM (1989, 1991) call for the development of mathematical literacy and power whereby all learners will be able to explore mathematical ideas, offer mathematical conjectures, reason logically, solve nonroutine problems, apply mathematics, and make decisions. However, in terms of equity, mathematics education in the United States is unevenly distributed along lines of social class (Secada, 1992) and economic background (Tate, 1995). While reform efforts advocate high standards for all learners, current educational practices continue to relegate a disproportionate number of learners from poor communities to remedial track classes (Oakes, 1990). By exaggerating the disparities between learners, the practice of tracking leads to differentiated outcomes. This educational differentiation further disadvantages already socially disadvantaged learners (Oakes, 1985).

Although the United States professes to have a democratic educational system, inequitable curriculum and pedagogy sustain the gap between marginalized and mainstream learners. Reform efforts emphasis on higher academic standards for learners has adversely affected at-risk learners, many of whom did not meet previous minimum standards (Garcia and Walker de Felix, 1992). Secada (1995) notes that the Professional Standards for Teaching Mathematics (NCTM, 1991) focus on a very narrow conception of teaching as what takes place within the confines of the classroom with regard to content. According to Secada, a broader conception of teaching, one that is not acknowledged by the Standards, takes into account pressing equity concerns. These concerns include learner access to advanced mathematics courses, perseverance in course taking, and, ultimately, participation in mathematics-related careers. It has been suggested that a useful strategy would be to take the rhetoric of goals and standards and wrap it in the same package as the equity agenda (Kozol, 1997, p. 18).

In an effort to remedy the disempowerment of marginalized learners, Cummins (1989) identifies five general principles for teacher education. In addition to adequate content knowledge, Cummins reasons that teacher preparation programs must prepare teachers to: (1) guide and facilitate rather than control student learning; (2) encourage students to work collaboratively in a learning context; (3) assist learners in establishing a genuine dialogue; (4) facilitate the development of learners higher level cognitive skills; and, (5) plan, design, and implement tasks that generate intrinsic rather than extrinsic motivation.

As Cummins (1989) implies in his general principles for teacher education, if learner empowerment is to be attained, teacher education programs must prepare teachers to guide learners to achieve their highest potential in mathematics. However, according to Kagan (1992), teacher preparation courses fail to provide teachers with adequate knowledge of classrooms, adequate knowledge of learners, the extended practica needed to acquire that knowledge, or a realistic view of teaching in its full classroom or school context. She cites five components of professional growth that are needed among novice and beginning teachers: (1) an increased awareness of what they know and believe about learners and classrooms; (2) an acquisition of knowledge about learners and the use of this knowledge to reconstruct their personal images of self as teacher; (3) a shift in attention in the design of instruction from self to student learning; (4) the development of standard procedures that integrate instruction and management; and, (5) growth in problem solving skills. These components of professional growth suggest that, in order to meet the criteria outlined by Cummins (1989), teacher preparation programs must provide preservice mathematics teachers, not only with extended practica, but with practica that give preservice teachers the opportunity to explore and cultivate instructional strategies that facilitate learners' acquisition of conceptual understandings.

METHODS AND DATA SOURCES

The methodological underpinning of this study is derived largely from orientations to research that draw attention to the importance of detailed qualitative fieldwork and the observation and analysis of participants in context; in this case, preservice teachers and learners (Goetz & LeCompte, 1984). A symbolic interactionist theoretical framework provided a foundation upon which to examine the experiences of preservice teachers and at-risk mathematics learners. Symbolic interactionists see meanings as social products. Many studies of school successes and failures have been profoundly influenced by symbolic interactionism. Symbolic interactionism's emphasis on how expectations embodied in social roles constrain behavior and interaction, and how interaction patterns lead actors to confirm or deny their prior expectations for the behavior of others, assists in explaining why students and teachers act in ways that appear counterproductive to their identities (Woods, 1979). Consistent with the purposes of the study, qualitative methods were utilized to: (1) examine the effect of engaging in a mathematics teaching experience in an alternative high school program on preservice teachers' beliefs, perceptions of at-risk learners, self-concepts, and instructional practices; and, (2) explore the effects of a guided preservice teaching experience on at-risk learners' beliefs, self-concepts, and mathematical development.

Setting and Participants

In order to collect sufficient detailed data to achieve the purposes of the study, data were gathered in four settings: (1) an alternative high school program; (2) a mathematics course for at-risk learners designed and taught by preservice teachers; (3) the preservice teachers' planning sessions; and, (4) a secondary mathematics methods course for preservice teachers. In order to provide for confidentiality, the participants, universities, schools, and programs referred to in this study have been given pseudonyms.

The College of Education at Inland State University, in partnership with the local school district, houses the alternative high school program, Transcend, on its campus. Transcend, which draws learners from the county-wide geographic area, can accommodate a maximum of fifty students. At the time this study was conducted, there were forty learners enrolled in Transcend. Learners who complete the program requirements receive a degree from the local high school. While learners may be recommended for the program by their counselor, teachers, or parents, their enrollment in the program is voluntary. Learners in Transcend are allowed a large amount of input into the design and composition of their program of study. However, the program meets all of the state's academic requirements, including the requirement that students earn four math course credits.

One group of participants consisted of five secondary preservice mathematics teachers who were engaged in a mathematics teaching experience at Transcend during the Fall 1997 semester. These preservice teachers were in the latter stages of a teacher preparation program at Inland State University, a large, public research university located in the northwestern United States. As a requirement for certification, the teachers were concurrently enrolled in the Secondary Mathematics Methods course.

The Methods instructor selected the preservice teachers to participate in the teaching experience at Transcend based upon his perception of the potential instructional success of the preservice teachers, the desire to have a diverse group of preservice teachers in the classroom, and the times during which the preservice teachers were available to teach. In addition, the Methods instructor sought to give consideration to novice and experienced preservice teachers as well as to traditional and nontraditional students.

A second group of participants consisted of the five mathematics learners who had been labeled "at-risk" and had elected to enroll in a mathematics class offered at Transcend during the Fall 1997 semester. The learners had been informed by the lead teacher and counselor at Transcend that the mathematics course would be taught by a group of five preservice teachers from Inland State University's teacher preparation program.

Procedures and Data Collection

The researchers spent a total of 190 hours engaged in data collection during a sixteen week period in the Fall of 1997. Consistent with the qualitative research methodology of the study, data were gathered from multiple sources, including: (1) observations, videotaping, and field notes of the mathematics classes and the Methods class; (2) observations, audio taping, and field notes of the preservice teachers' planning sessions; (3) structured and semi-structured, open-ended interviews (Novak & Gowin, 1984; Spradley, 1980) with the preservice teachers and the learners; (4) questionnaires on beliefs administered to both the preservice teachers and the learners; (5) document collection; (6) collection of classroom artifacts, including lesson plans, student assignments, and the preservice teachers' journal of observations of classroom activities; and, (7) a written, in-class mathematical assessment administered by the researcher and completed by the learners. These multiple data sources enabled the researcher to assess each dimension of the research questions in different ways and, as such, provided a kind of triangulation.

Data Analysis

A central principle of qualitative analysis is that theoretical statements be clearly emergent from and grounded in the phenomena studied; theory emerges from the data; it is not imposed on the data (Patton, 1980). The researchers utilized qualitative analytical processes to interpret and find inferences in the data in order to establish emergent patterns and address the research questions (Strauss and Corbin, 1990). As the analysis proceeded, the researchers were able to identify themes embedded within the data.

As the analyses of beliefs unfolded, categories of preservice teacher beliefs were further refined and clustered into the following groups: (1) mathematics as a tool consisting of a body of procedures vs. mathematics as a system of conceptual knowledge; (2) success through talent vs. success through hard work; (3) teaching through transmission vs. teaching through discovery activities; and, (4) one solution method vs. multiple solution methods. The researchers utilized these categories as method for connecting the preservice teachers' beliefs to their instructional practices.

Analyses of the preservice teachers' instructional practices were examined within the context of a four-tiered scheme. Lessons were characterized as: (1) teaching for understanding, which was defined as conceptually-focused, active and student-centered; (2) conceptually-focused teaching, which was defined as teaching that is focused on concepts, structure, and connections but does not involve a significant degree of student involvement; (3) procedurally-focused with student involvement, which was defined as teaching that is focused on algorithms, procedures, and sequences and is student-centered; and, (4) procedurally-focused without student involvement.

The analysis of the learners' beliefs was very similar to the analysis of teacher beliefs. As the analysis proceeded, categories of learner beliefs were refined and clustered into four groups: (1) mathematics as a tool consisting of a body of procedures vs. mathematics as a system of conceptual knowledge; (2) learning by listening vs. learning by discovery; (3) focus on the individual person vs. focus on the content; (4) one solution method vs. multiple solution methods.

In order to acquire information about the learners' mathematical development, including their general problem solving behaviors, the researcher analyzed videotapes of the mathematics classes at Transcend, field notes of the classes, interview data, and in-class assessment. The analysis of the development of the learners' skills and understandings focused on performance and comments that illustrated understandings of three mathematical topics that were central to the course instruction: (1) spatial sense and geometry; (2) number sense, including proportional reasoning, estimation, fractions, decimals, and percents; and, (3) functions and graphs, including variable, covariance, correspondence, and slope.

RESULTS

Case studies of three preservice teachers and two learners will now be presented. Implications and connections between these results follow.

Preservice Teachers

Discussions of the preservice teachers will focus on the relationships between their beliefs, perceptions of at-risk learners, self-concepts, and instructional practices. In exploring the instructional practices employed by the preservice teachers, the researchers examined the preservice teachers' efforts to teach for understanding and their use of (1) technology; (2) out-of-class experiences; (3) collaborative learning groups; (4) one-on-one instruction; and, (5) student comments to facilitate discussion.

Because teaching practices reflect teachers' beliefs which, in turn, reflect the teachers' own experiences and backgrounds (Cabello and Burstein, 1995), the researchers examined the relationships between the beliefs and instructional practices of three of the preservice teachers; Toni, Kevin, and Brad. These preservice teachers were selected for case studies, not only because of their diverse backgrounds and beliefs, but also because of their distinct instructional practices. While the majority of Toni's lessons were characterized as teaching for understanding, Brad's lessons were primarily procedurally-focused. The bulk of Kevin's lessons were dominated by two different instructional practices. Kevin's lessons were either conceptually-focused, without significant learner involvement, or procedurally-focused with a great deal of student involvement.

Brad

Like all of the preservice teachers who participated in this study, Brad was born and raised in Inland State University's host state. Brad was raised on a farm in a remote and sparsely populated region of the state. Because of positive experiences with school mathematics, Brad entered the study with a high mathematics self-concept. Consistent with his belief that the most important reason for teaching mathematics was to provide learners with mathematical skills, Brad's lessons were orderly and methodical. It appears that Brad developed his own teaching style by modeling the traditional teaching styles he observed in his high school and college mathematics courses; courses in which he was extremely successful.

During a lesson which utilized an open-ended, investigative approach to exploring the concept of volume, it appeared that Brad's ultimate intent was to have the learners utilize the formula for volume to determine the number of raisins in a box. The learners attempted various strategies, but none appeared to satisfy Brad. He interrupted the learners' discussion to offer his own strategy, "You could measure it, I'll tell you my way of doing it, is I measured in centimeters and I figured 1 cubic centimeter was equal to about 1 raisin, that's, and so you'd calculate the volume of the box."

Although the learners accepted Brad's teaching style and responded to his lessons, there was very little enthusiasm or spontaneous discussion during his teacher-centered, procedurally-focused lessons:

Brad: How about changing fractions into decimals, anyone have problems with that? [long silence]
Mollie: Top divided by bottom [pause] right?
Brad: Mmhmm. OK, walk me through, what's the first step? Anybody?

Brad identified his knowledge of mathematics as one of the strengths of his teaching. However, he identified as a weakness his difficulty in articulating his ideas in a way that would make them understandable to learners. While this contrasts with student-centered, investigative teaching strategies, it is consistent with Brad's procedurally-focused approach to instruction. He stated, "my strength I would say is that I know what I'm talking about, but the weakness is I have trouble verbalizing it."

Over the course of the semester, Brad's view of teaching and his own instructional practices began to evolve from a transmission, "pass-along" model to a more student-centered, facilitative model. For example, at the conclusion of the study, Brad stated that teaching at Transcend was a positive experience because it enabled him to try out instructional strategies from the Methods course in a classroom setting:

It was a lot better than other classes just 'cause it was practical experience instead of just sitting in a classroom learning about it, so, that's what really was nice about this. The thing I got most out of this was, it was just flat experience, and, I know that my first lesson that I taught was terrible, as compared to the tenth one I taught, and you know, you can take these ideas, and, that you've learned, and put them together, and that was the big thing, this thing was so much better than just writing them down in the classroom, the ideas, we actually got to try them out, and see which ones work or ones not work.

Kevin

Of the five preservice teachers who participated in this study, it was Kevin who appeared to have forged the strongest personal relationships with the students. Throughout the semester, Kevin worked at building and maintaining positive relationships between himself and the learners. His interactions with the learners may have been influenced by his beliefs about teaching mathematics. For example, Kevin identified caring as an important characteristic of a good mathematics teacher:

I think if they care about their students, they care about their students' learning, I think they're going to be a good math teacher.

Kevin's belief that the most important reason for teaching mathematics was to improve the self-esteem of learners was evident in observations of Kevin's student-centered instructional practices. While many of Kevin's early lessons were procedurally-focused and predominantly teacher-centered, as the semester progressed Kevin began to integrate open-ended activities based upon real-life examples into his lessons. For example, he utilized snowboarding to engage the learners in a discussion of angle measure:

Kevin:	Ok, you guys, I see you guys are at least familiar with these kinds of things, right? You guys ever think of kick flips you might do, kick flips, skateboarding, what kind of tricks might you do?
Mollie:	Like 360 and 180 and those things.
Kevin:	One of my friends, whose my best friend, loves to go boarding, and uh, he can do 720s, you guys know what that is?
Mollie:	You spin around, er, 2 whole circles.
Kevin:	Right, so we're talking about different tricks, come up with a different ones, we talked about the 180, the 360, 720s, do we know what all that stuff means?
Jamie:	Circles?
Kevin:	Circles.
Jamie:	Degrees of circles.
Kevin:	Degrees of circles, so what do you guys know about degrees of circles?
Mollie:	Uh, full circle is 360.
Kevin:	So start, basically a reference point, right, you were facing this way, you jump around 360 degrees, you come back to the same place, and when it's 0, you don't jump at all right? Now what if you do a 180? If I'm facing this way, what way would I face when I do a 180?
Wendi:	You're going to be the opposite way.

Kevin's use of innovative instructional strategies may have been related, in part, to his beliefs about at-risk learners. Kevin believed that at-risk learners were unmotivated students and, as such, "you have to provide them a hook, a why, whatever's important to them, that's the big thing." Observations of Kevin's teaching revealed that he did indeed try to provide the learners with a "hook" at the beginning of each lesson.

Of the five preservice teachers who participated in this study, Kevin was the only teacher who explicitly articulated how his beliefs about mathematics were changed as a result of his experiences at Transcend:

> It's interesting teaching math because, I have to go back and re-learn it, I'll know the stuff and I can do the stuff but to teach math, you need to understand all the concepts, it takes up, it takes a lot to rethink, ok, why is this, and, what is this, so I learned a lot of, and I know I will re-learn a lot of stuff in math when I'm teaching it, just, stuff that I know, the concept of, but then I have to, to really explain, you have to know all the concepts so, you almost have to re-learn math that way so you can you explain it, effectively.

Toni

Because of negative experiences with school mathematics, Toni appeared to have an extremely low mathematics self-concept. However, Toni's metaphor for mathematics revealed that, even though she struggled with the underlying concepts of mathematics, she enjoyed the subject:

> Math is just this giant banquet, you help yourself to, you know, there's all kinds of things you pick and choose from and they're all delightful, most of them anyway.

Toni's negative experiences with traditional mathematics instruction appear to have encouraged her to attempt to teach for understanding. In addition to her willingness to experiment with open-ended, investigative activities, Toni attempted to design student-centered learning environments in which the learners could explore the concepts underlying the mathematical topics. For example, in order to teach a lesson on ratio, scale, and proportion, Toni arrived in class with a large carpet bag that was overflowing with a variety of miniature dollhouse tools, life-size tools, measuring tapes, rulers, pencils, and magazines. At first, each learner selected a miniature tool, paired it with a life-size tool, and then attempted to determine the scale between the tools. The learners were next given schematics of birdhouses and asked to determine the scale. Perhaps because of the novelty of the materials, all of the learners were extremely attentive and involved in the lesson.

Toni was extremely willing to integrate many of the ideas from the Methods course into her own instruction. In the following excerpt, Toni was attempting to teach the concept of area for understanding. In addition to engaging all of the learners, Toni appeared to have some measure of success in eliciting learner explanations:

Toni: If you have this, um, same, dimensions, 3 by 5 [points to a 3 x 5 rectangle], but, somebody comes along and goes, shifts it all that way, right [draws a 3 x 5 parallelogram] [pause] now we've got um, we've still got 3 inches here, and you've still got 5 inches here, and you've still got 3 inches here, and then we've got 5 inches here, are we going to have the same area in here? Is that area going to be 15?

Rianne: No.

Toni: Are you sure? [pause]

Johnny: How could it change it?

Toni: That's a good question, when I slant it what happens, what happens here?

[At this point all of the learners were clearly engaged in the activity.]

Johnny: The angles change.

Toni: Here's my 3 by 5, and here I have, a 90 angle, and here I have a less than 90 angle.

Jamie: It's still all going to be 360.

At the conclusion of the semester, Toni revealed how engaging in the teaching experience at Transcend enhanced her teaching self-concept:

Being able to, make mistakes, and, and, recover, and, scramble, to fix things, that was definitely, a helpful thing, to me, that was one of the most helpful things to me, I think, being able to do that.

Discussion

Although the preservice teachers were able to teach in conceptual realms on occasion, the majority of the instruction was procedurally-focused, but student-centered. There were six specific reasons identified for these tendencies: (1) the rotating teaching schedule; (2) learner resistance and lack of knowledge; (3) lack of direct guidance on how to implement "conceptual activities"; (4) teachers' beliefs and attitudes; (5) initial perceptions of the "at-risk" learners; and, (6) concerns about classroom management issues.

For example, while all of the preservice teachers indicated an intent to facilitate discussion, they revealed that, because they were simultaneously focused on a variety of other teaching issues, they were not always able to recognize and react to student comments. Their lack of experience orchestrating whole-class discussions of mathematical topics may also have inhibited their ability to engage learners in discussions.

Learner resistance was another reason for the discussions being procedurally-focused rather than conceptually-focused. For example, when Toni presented a rectangle model to illustrate the concepts underlying the addition of fractions, the learners began mumbling that they did not understand what Toni was trying to demonstrate. As the lesson proceeded and learner resistance to the conceptual focus increased, Toni transitioned to a procedural focus.

Learners

This section details the mathematical development of two learners, Mollie and Jamie, as they progressed through the course. Due to space constraints, the discussion will focus less on aspects of beliefs and self-concept and more on mathematical content development. Although all five learners obtained very different outcomes from their experiences in the course, the results below provide insight into the overall effects of the instruction on the learners.

Mollie

Throughout the year, Mollie focused on notational and procedural aspects of the mathematics being discussed. However, there were several instances where Mollie showed solid understandings of the underlying structure of a given mathematical procedure or concept.

Geometry and Spatial Sense. Entering the course, Mollie had little experience or knowledge with geometry. However, by the end of the year, Mollie was able to investigate areas by triangulating given polygons and was skilled at approximating area by using gridded transparencies. She also become fluent with area formulas for rectangles and triangles, and had a tenuous hold on the formula for the area of a circle.

Evidence on her sense of the processes of finding area indicates that she learned these skills with some degree of understanding. During Interview 3 she displayed spatial sense by noting that a parallelogram was "a rectangle that's been sort of slanted." Three days before this, during an in-class activity in which regular n-gons inside a fixed circle were being observed, she noticed that the limit of the area of the n-gons would be the area of the circle. The instructor then produced a graph of number of sides vs. area for several different n-gons. However, despite her observations and the presence of the graph, she continued to demand to use formulas to find area, stating, "Well, tell me the formula and I'll do it, what's the formula?" The instructor immediately supplied Mollie with the formula for area of the circle, and she used this to complete the task.

During the final interview, Mollie illustrated how far she had developed in regard to an understanding of area. Given a trapezoid of height 7 and bases 12 and 18, Mollie divided the area into two triangles and a rectangle. When asked to find the area, she said, "Do you want me to do the math?" She then calculated the area of the rectangle (7x12), and then computed 18-12=6 to get the combined length of the bases of the two triangles. She then computed (1/2)*6=3 and 3x7=21 to get the combined area of the two triangles, which she then added to the area of the rectangle to obtain the solution. This problem solving process indicates an ability to break down area into component parts, knowledge and proper use of area formulas, and solid problem solving skills.

Number Sense. Mollie was heavily focused on notation when performing arithmetic operations on fractions and decimals. During the second and third class sessions, when encountering addition and subtraction tasks, she expressed a need to write fractions "up and down" so that they could more easily be converted into fractions with common denominators. She was fluent in procedures on fractions, indicating the process of multiplying fractions was to "multiply across."

Mollie expressed a resistance to thinking about fractions in more conceptual realms. During the second class session in which Toni introduced an array model for fractions, Mollie seemed to follow the ideas being discussed, but indicated that she preferred to find common denominators and continued to problem solve this way:

Mollie: This is how I learned it, like this, just go [comes up to board and writes it] and then you do the common denominator, the lowest common denominator which is 6, and then you go like this [writes out] and then, or, and then 2 plus, times 3 is 6 and then 1 times 3 is 3. [pause]

Toni: Right. [pause]

Mollie: That way is easier.

In the next class session she reiterated her resistance to the array model.

At the end of the year, Mollie continued to struggle with fractions and decimals. She stated that 1/2 was less than .3 because "I turned them all into decimals". An inability to properly convert a fraction to a decimal may have led to this confusion. However, a reliance on procedure and limited number sense did not allow Mollie to think about 1/2 as .5 and quickly compare the magnitudes of these numbers.

However, Mollie showed good use of proportional reasoning on numerous occassions. For example, using the fact that the football field on a campus map was 1.5 inches, Mollie was able to deduce the scale factor for the map. Mollie showed very consistent and spontaneous use of proportional reasoning throughout the course.

Overall, however, it appears that the instruction did little to influence Mollie's procedural tendencies when thinking about number and associated arithmetic operations. This is particularly true in regard to operations on fractions and decimals as well as tasks with large numbers.

Functions and Graphing. Mollie entered the course with minimal understandings of functions and graphs due, in part, to bad experiences with past courses. Over the course over the semester, Mollie made considerable gains in her understandings and abilities associated with various algebraic topics. Mollie quickly mastered the ability to generate literal expressions given statements such as "3 less than twice a number", and she used this ability to generate equations in various problem solving situations throughout the course. Mollie also showed understandings of functions throughout the course, particularly in regard to understanding the correspondence relationship between x- and y-values. However, her understandings of the connections between equations and graphs, slope, variable, and covariance were less well-formed. For example, consider the following dialogue from an activity in the middle of the year:

Mark: I just, I wanted to, this is something I want you to think of for a second. If y = 2x+1 is one line, now we haven't graphed anything like that, have we? And y = 2x-5, do you think they'd be parallel or not, what do you think?

Mollie: They'd be parallel?

Mark: Why?

Toni: Why do you think?

Mollie: Cause they're both, you're times-ing both by 2, times the x by 2.

Mark: So what does that say about how it would be graphed?

Mollie: That you'd be going 2 over.

Mark: 2 over.

Mollie: And then 5.

Mark: 1 over and 2 up?

Mollie: Yeah, 1 over and 2 up.

Mollie's tendency to find slope by dividing the constant term by the coefficient of x stayed with her throughout the year. However, at times she would also interpret slope using the coefficient of x in a more appropriate manner. The following discussion involved the function $f(x)=3x+7$:

Toni: What would be the slope?
Mollie: The 7?
Wendi: The 7, 'cause the 7 makes the difference in whether it increases or
Mollie: No, no, no, no, no. It would be the 3, it's what you times x with.
Jamie: You keep saying y equals, all this equals to that one line, going up?
[long pause]
Mollie: You're just trying to find out what x and y are.
Wendi: Uh, uh, uh!!! That's all I'm going to say.
Toni: Right now, all I want, what I want to find out
Mollie: Forget the parallel.
Toni: is what's the slope?
Mollie: Slope, 3, it's what you times the x by, and it makes it get bigger and smaller, makes the slope increase and decrease.

Overall, Mollie's ability to appropriately analyze slope using graphs, tables of values, and story contexts suggests that her understandings of the meaning of slope were driven somewhat by functional notation, but that she had a sense of slope as a constant rate of increase.

Mollie seemed to continue to struggle with algebraic notation late in the year. During a year-end review she stated that $y=3x-2$ would have a slope of "3 over and up 2", and then participated in a discussion that revealed extreme difficulties in numerically interpreting fractional slopes. As in the case of her understandings of number concepts, it appears that Mollie had difficulty understanding the structural ideas behind certain symbolic notations.

Jamie

Jamie displayed both procedural and conceptual gains throughout the course. These gains were primarily in the area of geometry, as she continued to struggle with numeric ideas and algebraic symbolisms by the end of the semester. These struggles were compounded by her personal problems which disrupted her course attendance during the final three weeks.

Geometry and Spatial Sense

Jamie entered the course with virtually no background in geometry, but made great strides in her knowledge of geometry throughout the course. Jamie made the most progress in the development of spatial sense with repsect to area of polygons. She displayed solid understandings of the process of triangulation, and was able to use these understandings in making sense of the interior angle measure formula for polygons. Jamie was also able to apply these understandings of triangulation to polygons that were not convex.

During the middle of the course, Jamie was presented with a task of comparing and contrasting a rectangle and a parallelogram with equal bases. Although she makes inappropriate statements about right angles in the following passage, she appropriately applies and illustrates a conceptual understanding of the interior angle formula:

TD: Can you say anything about the angles?

Jamie: The angles? Um, they all have 90 degree angles, they're all 360.

TD: Ok, how do you know that?

Jamie: Well, I think of, the equation that we made up, that 4 sides, like, minus 2 [pause] um, 4 sides minus 2, 'cause I think of like, triangles, like that, where 2 triangles, so it's like 4 minus 2, times 180.

TD: Right, mmhmm, good, would that be the same or different for this guy over here (the parallelogram)?

Jamie: Mmm, it'd be the same, because that's 4 sides, and you can still split that up into 2 triangles.

DS: You said they all have 90 degrees, is that, is that what you said a while ago?

Jamie: Like, how they showed us how to do that [marks two 90 degree angles with pencil on the rectangle] like that.

DS: What about the other figure (parallelogram), do they have 90 degrees too?

Jamie: Um, yeah, it's a total of 360, they're all going to be 90 degrees, 90 degree angles.

Four days later, in the following class session during a similar discussion of rectangles and parallograms, Jamie gave more appropriate attention to individual angle measures.

Jamie seemed to struggle with measurement concepts in relation to circles, perhaps because of her inability to fully understand angle rotation or her lack of understanding of pi. Overall, Jamie displayed solid understandings of measurement concepts and spatial sense throughout the semester. Given her relatively little experience with geometry prior to the course, it appears that Jamie gained a considerable amount of insight from the geometric portions of the course.

Number Sense

Jamie approached most arithmetic tasks and contexts in a procedural manner. Very early in the year, when faced with the task of adding 1/3 and 1/4, Jamie stated, "You have to get the bottom to be 12."

She later successfully described the procedure for dividing fractions. When encountered with an array model for fractions, she saw no point in thinking about fractions this way. In the next class, she made the following statement in regard to this conceptual model:

Jamie: I don't understand what you're doing when you do it visually.

Clearly, Jamie preferred to work with fractions in purely procedural realms. As in the case of Mollie, this procedural focus had consequences on her ability to perform related computations. After a lengthy discussion of converting fractional stock shares into percentages, Jamie stated, "I don't know how to change fractions to decimals." It seems that Jamie focused only on learning a method of converting shares to percentages and did not realize the more general applicability of this skill.

However, despite her lack of number sense associated with fractions and decimals, Jamie showed procedural and conceptual understandings of ratio and proportion. During a class session in the middle of the course she was able to successfully perform several scaling tasks. At the beginning of the next class session, Jamie was able to summarize what had been learned:

Kevin: Who can tell us about ratio?
Rianne: Ratio is a comparison, like chairs to tables, boys to girls.
Kevin: Ok.
Jamie: 6 chairs to 3 tables.
Kevin: Ok, so it's like a ratio of number of guys to girls.
Rianne: Or girls to guys.
Jamie: But we went way in depth more than that.
Kevin: Right.
Jamie: We had these big wrenches like this and then we looked at little wrenches like this and you had to figure out how we

could get that big size down to the exact little size was what it was.

Rianne: You divide it.

Kevin: Right.

Jamie: Divide the little number and you get that like

Kevin: So the concept of a ratio is comparing 2 things right, using like the quantity of them or the length, you could do that, you could probably do it for weight, for different things like that, um, now what do we know about scale?

Jamie: Wasn't, maybe that, scale, I don't know, like, what I just said would be scale.

Overall, Jamie continued to think about numbers and arithmetic tasks in procedural realms, showed little understanding of fraction and decimals, but on several occassions demonstrated solid proportional reasoning ability.

Functions and Graphing

Jamie showed limited development of understandings of functions and graphs throughout the course. As mentioned earlier, she entered the course with negative feelings towards these topics. Her abilities were also low, as she struggled with standard algebraic notations. She had great difficulty constructing literal expressions from phrases such as "2 less than 3 tmes a number" early in the year. Throughout the year she was not able to solve equations such as 10+2x=24, and she initially could not construct an equation to model a linear context. Her in-class experience with the pizza problem generated some understandings of modeling, as by the middle of the year she was able to model a linear context, but stated that "it's kind of hard to think without referencing it to pizza." Jamie also showed great difficulty solving linear equations which were not in a proportion context. The latter were usually written as fractions and required cross-multiplication to solve.

The pizza problem illustrates Jamie's tendencies to prefer to think in procedural realms in the context of functions. When the problem was being introduced, Jamie appeared interested and involved in the context. When told that she would get $3 for each piece of pizza she ate, Jamie stated, "I'd make sure I ate a whole pizza!" As the discussion ensued, she made several insightful comments and created a solution strategy to a contextualized linear equation task:

Toni:	Here's my pizza, it's still the same price. So let's take $7 to get in, what if we had $29 when we walked out? [long pause] Let me finish that question, if we had $29 walking out, how many slices of pizza did we eat in the party? [long pause]
Jamie:	12?
Toni:	And how did you get that?
Jamie:	I added the 7 and divided it by 3.
Toni:	Ok, ok, [pause] you added the 7 to?
Jamie:	29
Toni:	The 29, ok.

However, her problem solving strategy was done without the use of algebraic symbols, and she continued to struggle in this domain throughout the course. However, Jamie later understood x to be "whatever number", and also mentioned that x would be "slices of pizza" in the pizza problem context. Her general understandings of functions were heavily related to the pizza problem context, but she did make some generalizations in regard to variable and correspondence.

By year's end it was clear that Jamie had never learned or forgotten most of the algebraic ideas discussed during the course. At the end-of-year review, when asked for an example of a function, Jamie stated, "that pizza one." However, she had trouble modeling an equation for this now very familiar context, and she did not seem to be able to talk at all about general linear properties such as slope and intercepts. Jamie left the course with very little understanding of functional ideas or sense of algebraic notation.

SIGNIFICANCE AND IMPLICATIONS

Over the course of the semester, there were changes in the preservice teachers' self-concepts, perceptions of at-risk learners, and instructional practices. Although they impacted instruction in various ways, for the most part, the preservice teachers' beliefs remained unchanged by the teaching experience. It appears that the preservice teachers' beliefs were rooted in their prior educational experiences. However, the teaching experience did appear to have a positive effect upon the preservice teachers' self-concepts and perceptions of at-risk learners. In turn, the preservice teachers' self-concepts and perceptions of at-risk learners effected their instructional practices.

In an effort to determine the effect of the teaching experience on instructional practice, the researchers examined several issues related to instruction. Those issues which appeared to have had an impact on instructional practice include the preservice teachers' beliefs, backgrounds and experiences with school mathematics, perceptions of at-risk learners, and self-concepts. The learning patterns of the students at Transcend also appear to have impacted instructional practice.

Prior to the start of the semester, the preservice teachers expressed concerns about anticipated behavior and capability of the at-risk learners. These initial perceptions of the at-risk learners encouraged them to design a "semester of life skills mathematics." However, as the semester progressed, and the preservice teachers developed enhanced perceptions of the at-risk learners' capabilities and motivation, the focus of the course evolved from life skills to algebra and geometry.

The preservice teachers' concerns about the learners' personal lives also impacted instruction. For example, apprehension about personal and family situations interfering with the learners' ability to complete out-of-class assignments resulted in the preservice teachers not providing the learners with homework. This, in turn, appeared to have had an adverse impact on the learning, as the learners were not provided with sufficient opportunities to reflect upon the mathematical topics and concepts covered in class.

Concerns about the learners' relationships with one another, as well as their ability to collaborate, persuaded the preservice teachers to limit group work. Similarly, the preservice teachers' concerns about classroom management issues resulted in their eliminating exploratory activities, including out-of-class experiences from their curriculum.

The preservice teachers' own traditional backgrounds and experiences with school mathematics appeared to have prepared them for procedural rather than conceptual instruction. In some instances, the preservice teachers' low self-concepts may have inhibited them from pursuing open-ended, conceptually-focused strategies.

It was not possible to clearly establish the preservice teachers conceptual understandings from the data. However, it is possible that the preservice teachers' own weak conceptual understandings may have inhibited their ability to teach conceptually. The data do suggest that the preservice teachers lacked pedagogical content knowledge.

The students' learning patterns also appear to have influenced instructional practice. For example, the learners' reluctance to engage in mathematical discussions and their resistance to open-ended exploratory activities often encouraged the preservice teachers to abandon conceptually-focused instruction.

These instructional practices seemed to produce learning gains on the part of the students, particularly in regard to spatial sense and geometry. In addition, the students generated functional understandings of correspondence, variable, and slope, but these were heavily imbedded in the context of the pizza problem. All of the students maintained a procedural focus on arithmetic operations throughout the course, and were quite reluctant to approach arithmetic thinking in a conceptual way. However, the students did show a solid ability to reason proportionally and apply this knowledge in appropriate contexts.

The largest student gains, however, appeared to occur in regard to the learners' increased mathematical self-concept. All five of the students entered the course with an "at-risk" label and negative mathematics classroom experiences in the past, particularly in the middle and high school level. The instructional style, one-on-one attention, and perceived success by the learners led to positive contributions from the learners to the overall classroom environment, a willingness to learn, and mosltly positive learning behaviors. The students appeared to leave the course with much more confidence in their ability to do and understand mathematics. The data suggest that student learning gains did occur, but the students remained weak in several mathematical areas in regard to both skill and understanding.

Transcend appears to have provided both preservice teachers and learners with a unique environment which enhanced mathematics teaching and learning. By encouraging individual contact between the learners and the preservice teachers, Transcend enabled the preservice teachers to provide student-centered, individualized instruction that led to gains in students' mathematical self-concepts as well as qualified gains in regard to mathematical content development.

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