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Math Links: Building Learning Communities in Urban Settings[1]

Jacqueline Leonard
Temple University

Brian R. Evans
Pace University

Learning mathematics in urban settings is often routine and decontextualized rather than inquiry- and culturally based. Changing prospective teachers' attitudes about pedagogy in order to change this pattern is often tenuous. The purpose of this pilot study was to provide opportunities for teacher interns enrolled in a graduate certification program to interact with urban students in a community-based program called Math Links. Twelve interns completed 30 hours of fieldwork at church-based sites. Prior to fieldwork, the interns participated in a 3-hour professional development and education session, in addition to their education courses. Three interns' work with urban children and youth reveal that community-based experiences changed their attitudes about practice and their capacity to teach urban children mathematics in culturally sensitive ways. One in-depth case study of an Asian teacher reveals not only changes in her attitudes and beliefs about urban students but also changes in her pedagogy as she shifted from teaching by telling to guided inquiry.

KEYWORDS: "at-risk" students, community-based programs, mathematics education, teacher interns

For more than two decades, there has been an impetus of reform in mathematics education (Martin, 2003, 2007). As mathematics teacher educators, we have focused on reform-based pedagogy in our elementary and secondary mathematics methods courses with the intent to inform preservice and beginning teachers in undergraduate and graduate teacher credential programs about the advantages and challenges of using reform-based practices.

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JACQUELINE LEONARD is an associate professor of mathematics education in the College of Education at Temple University, 1301 Cecil B. Moore Avenue, Ritter Hall 434, Philadelphia, PA 19122; e-mail: jleo@temple.edu. Her research interests are equity and access issues as they pertain to mathematics education and teaching for social justice and cultural relevance in the mathematics classroom.

BRIAN R. EVANS is an assistant professor of mathematics education in the School of Education at Pace University, 163 William Street, 11th Floor, New York, NY 10038;email: bevans@pace.edu. His research interests are social justice in urban mathematics education and international mathematics education. He is also interested in alternative certification and pre-service teacher preparation in mathematics.

Reform-based practices in mathematics classrooms can be viewed in one of two ways: use of reform-based curriculum and/or use of reform-based pedagogy. Studies on reform-based curriculum show that teacher educators can successfully guide preservice teachers in developing conceptual knowledge in mathematics (Ebby, 2000; Sherin, 2002; Spielman & Lloyd, 2004). In addition to the use of reform-based curriculum, reform-based pedagogy, such as teaching for understanding (Ball, Hill, & Bass, 2005; Ma, 1999; Sherin, 2002), facilitating classroom discourse (Cazden, 2001; O'Connor & Michaels, 1993), and engaging in culturally based practices (Brenner, 1998; Leonard, 2008; Lipka et al., 2005) are common elements found in reform-based classrooms. Yet, effective reform-based teaching of mathematics requires that preservice teachers learn by actively engaging students in the teaching-learning process (Ambrose, 2004; Ebby, 2000; Lowery, 2002; Sherin, 2002). Thus, it is important for preservice and beginning teachers to have opportunities to apply the knowledge they gain from theory and research in education courses to real settings where they can implement reform-based practices with children.

For the purpose of this article, reform-based teaching is characterized by inquiry and culturally sensitive approaches to teaching and learning. In an inquiry-based approach, the roles of teachers and students are redefined. The teacher is no longer the sole authority for building mathematical knowledge in the classroom (National Council of Teachers of Mathematics [NCTM], 2000). Instead students are encouraged to be proactive rather than passive, using their own knowledge and experience to justify solutions to mathematics problems. The *Principles and Standards* document (NCTM, 2000) provides an impetus for reform-based teaching in mathematics. The document falls short, however, when it comes to cultural pedagogy (Leonard, 2008; Leonard, in press; Martin, 2007). Focusing only on content knowledge, without attending to pedagogy (Ball, Bass, & Hill, 2005) or the students' culture (Ladson-Billings, 1995; Nieto, 2002), does not lead to the development of high-quality teachers (Martin, 2007). Because mathematics is not divorced from culture, teachers must also be culturally competent in order to be prepared to work with diverse student populations (Ladson-Billings, 1995).

Knowledge of diverse students' learning styles and cultures helps teachers, especially those who are from different racial, ethnic, and/or social backgrounds, to develop strong teacher–student relationships with culturally diverse students (Lipka et al., 2005; Shade, Kelly, & Oberg, 1997; Silverman, Strawser, Strohauer, & Manzano, 2001). Culturally sensitive approaches should also link mathematics to issues of social justice. Teaching for social justice empowers historically marginalized students to use mathematics as a form of liberation (Gutstein, 2006). Diverse students are more likely to realize the importance of learning mathematics if it can be used to empower them to change their circumstances (Gutstein, 2006; Ladson-Billings, 1994; Leonard, in press).

Yet, teaching preservice and beginning teachers reform-based strategies is not a panacea. As methods instructors, we have found these teachers' beliefs and prior experience cause them to be resistant, initially, to reform-based practices. Among preservice teachers enrolled in our teacher credential program, a significant number did not experience any kind of reform-based teaching. Essays written in our mathematics methods courses revealed that some preservice and beginning teachers continue to be taught mathematics in traditional ways as Osisioma and Moscovici (2008) had found in a similar study with science teachers. These preservice and beginning teachers were often taught to use rules and algorithms to solve problems and were not allowed to question the teacher or their peers in the learning context. Excerpts of three preservice teachers' reflections of their previous experiences in K–12 mathematics classrooms are presented for consideration:

> I remember my previous math teachers back in middle school, and they did not incorporate any hands-on activities into their lessons. It was simply learning off what was on the board. I think I would have been less intimidated by math if I had materials and engaging activities to help me to learn the concepts. (female student, fall 2007)

> For the most part, I don't have a lot of clear memories of how exactly I learned math. This is probably because the teachers I had rarely did anything extraordinary to support their lessons. I do remember in second grade doing something called a Mad Minute, which were 30 addition and/or subtraction problems that we had a minute to try and complete. Also, in second grade, we could earn fake money for doing certain things in class, and every other week or so we would have an auction where we could spend that money on small prizes. Other than that, I honestly don't remember anything specific from elementary school regarding learning math. (male student, fall 2007)

> What I can remember from math classes when I was younger involves a lot of scrap paper and many trips to the board. We would be given pages and pages of homework, sometimes without the concept even grasped. I just remember asking the question why a lot and never getting an answer. Many math teachers are just concerned that you can actually solve the problem, rather than why it is solved like that. (female student, fall 2007)

These excerpts reveal that despite almost 20 years since the publication of the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) the teaching-learning context in K–12 mathematics classrooms has not dramatically changed (Martin, 2003). Mathematics instruction continues to be disconnected from students' culture and everyday experiences (Silverman et al., 2001). Mathematics, as a content domain, continues to be viewed as a complex series of algorithms with abstract entities that have nothing to do with the sociocultural context of students' lives.

These experiences are more pronounced among candidates in our graduate certification program, who tend to be older adults planning to teach as a second career or young adults with bachelor degrees in liberal arts who want to obtain a

teaching credential. These candidates are able to obtain jobs as teacher interns while completing the credential program. In this study, a teacher intern is defined as one who has a paid or unpaid field experience in an informal or formal school setting. In some cases, teacher interns have full-time jobs as teachers while they are taking courses at night. A recent study of science teacher interns revealed that it is possible to change teacher beliefs among this population (Osisioma & Moscovici, 2008).

Osisioma and Moscovici (2008) examined nine science teacher interns' beliefs about inquiry and reform-based methods of instruction before, during, and after taking two science methods courses. Osisioma and Moscovici collected data from written reflections, lesson and unit plans, interviews, observations, class discussions, and peer-teaching in the methods courses. They found most participants primarily used traditional methods of instruction and were more teacher-oriented. At the end of the two methods courses, the researchers found the number of interns who believed in the use of inquiry and student-centered instruction rose to seven from initially only one. The authors concluded that beliefs about science teaching and learning changed over the two semesters and recommended that this area of research receive greater attention.

To address teaching mathematics from a cultural and social justice perspective, we studied the impact of reform-based practices learned in two graduate teacher education courses and the enactment of reform-based pedagogy in community-based settings. It is in such settings that prospective teachers' perceptions of urban students of color might change. Too often, perceptions of African American and other underrepresented minority students are rooted in deficit theories that contend these students are "less than ideal learners and, therefore, in need of certain kinds of teachers" (Martin, 2007, p. 8). More often that not, these teachers are strong in discipline but weak in mathematics content knowledge and cultural sensitivity. Some African American scholars (Gay, 2000; Ladson-Billings, 2006; Leonard, 2008; Martin, 2007; Nasir, 2005) call for teachers to use students' cultural experiences as a springboard for learning mathematics. In this article, we are particularly interested in how K–12 teacher interns interacted with urban students who were enrolled in an after-school program or a specialized program for "at-risk" high school students. The purpose of this article is to report on the enactment of reform-based practices in these non-traditional urban settings. Because students in such settings are often marginalized, a framework that connects issues of social justice with education is needed.

Theoretical Framework

This pilot study is grounded in a framework that has social justice at its core. The ability to view the world through the eyes of marginalized persons is critical to developing culturally sensitive approaches to teaching (Gay, 2000; Nieto, 2002;

Shade et al., 1997). Paulo Freire in *Pedagogy of the Oppressed* (1970/2000) described the importance of *conscientização,* which is the development of the skills necessary for critical consciousness and the teaching of social justice (Apple, 2003; Gutstein, 2003). To operationalize *conscientização*, however, a specific type of emancipatory pedagogy is needed. Culturally responsive teaching/pedagogy is one such framework (Gay, 2000).[2] According to Shade and colleagues (1997), culturally responsive pedagogy builds bridges between the culture of the school and the home. They contend that knowledge should be transmitted in three areas: general skills needed for survival (reading, writing, and mathematics); cultural information (art, science, and history); and cultural norms (behaviors and mores). Yet, the debate continues over whose knowledge is valued and taught as official (Apple, 1995). White-middle class values and examples dominate the American educational system while the contributions and values of persons of color are often neglected (Blanchett, 2006; Gutstein, 2006; Leonard, 2008). Freire's construct of *conscientização* challenges this perspective from a class perspective while culturally responsive pedagogy grounds our work in racial and social justice.

Gay (2000) contends that culturally responsive pedagogy is crucial in motivating urban students of color to learn. Culturally responsive pedagogy derived from multicultural education paradigm in the 1970s; it "simultaneously develops, along with academic achievement, social consciousness and critique, cultural affirmation, competence and exchange; community building and personal connections; individual self-worth and abilities; and an ethic of caring" (p. 43). One of the most consistent and powerful findings of research studies related to diverse students' academic achievement is the ethic of caring (Gay, 2000). The ethic of caring is demonstrated by teacher attitudes, expectations, and behaviors related to children's intelligence and academic success (Gay, 2000). Caring teachers believe their students are competent and hold them in high esteem. Students then live up to teachers' expectations and exhibit appropriate classroom behaviors (Gay, 2000; Ladson-Billings, 1994). Culturally responsive pedagogy, then, is an important aspect of the teaching-learning environment in urban school settings. Thus, we use the constructs of *conscientização* and culturally responsive pedagogy to ground the Math Links study.

Research Questions

The research questions that emerged in the Math Links study were: (1) How does one teacher-researcher's reform-based practices influence teacher interns' be-

[2] Gay (2000) uses the concept *culturally responsive teaching*; whereas, Ladson-Billings (1994) uses the concept *culturally relevant pedagogy*. For a brief discussion of the similarities and difference of concepts that might be positioned under the umbrella of *culturally responsive/specific pedagogy* see Leonard (2008).

liefs about culturally responsive pedagogy? (2) How does interaction with urban youth in a community-based internship influence the development of culturally responsive pedagogy among teacher interns? To answer these questions, we conducted a year-long study with two cohorts of teacher interns to draw on data collected and analyzed on participants enrolled in two types of education courses in our graduate teacher certification program: elementary mathematics methods (fall 2006) and effective teaching (spring 2007).

The Math Links Study

The Math Links pilot study grew out of a similar study in science that studied changes in preservice teachers' science instruction when they engaged in community-based internships (Leonard, Boakes, & Moore, in press). The Math Links pilot study was designed to obtain process data about the supports and resources needed to empower teacher interns to practice reform-based teaching in K–12 diverse school settings. The purpose of the Math Links pilot was two-fold: (1) to provide teacher interns with field-based experience to practice reform-based mathematics instruction; (2) to provide teacher interns with critical understanding of culturally responsive pedagogy. By exposing teacher interns to urban students enrolled in informal school settings, we aimed to reduce stereotypes about urban children and youth and to increase the capacity of prospective teachers to engage in reform-based mathematics instruction and culturally responsive pedagogy.

Study Sample

A total of 12 preservice teachers (4 undergraduate and 8 graduate) were recruited to participate in the study. Six preservice teachers (1 undergraduate and 5 graduate) participated in fall 2006, and six preservice teachers (3 undergraduate and 3 graduate) in spring 2007. Some of our participants were secondary majors and some were elementary majors. The variety of participants' backgrounds adds important caveats to our data analysis. However, the population of interest was preservice and beginning teachers enrolled in a graduate certification program. As previously mentioned, the rationale for studying this population is studies on this particular population are scarce and these teacher candidates have few if any field experiences in education prior to student teaching or induction (Osisioma & Moscovici, 2008). The ages of the eight interns selected from the larger study ranged from 25 to 39 years of age. Five were White women, two were White men, and one was a Korean woman.

The Teacher-Researcher

One of the teacher-researchers of this study was also the instructor of the courses in which the teacher interns were enrolled. One of the courses in which the interns were enrolled was an elementary mathematics methods course (fall 2006), and the other course was a general pedagogical course on effective teaching (spring 2007). The teacher-researcher will be referred to as Bridget (pseudonym) for the sake of anonymity. Although these were two different courses, Bridget's philosophy of education was consistent in both courses. Her strong belief in equity and social justice influenced the texts and articles students read in the courses. Students in the pedagogy course read texts that dealt with cultural relevance and social justice on a general level (i.e., Gloria Ladson-Billings' AERA presidential address [Ladson-Billings, 2006], *The Dreamkeepers* [Ladson-Billings, 1994] and *Diversity Pedagogy* [Sheets, 2005]). Students in the mathematics methods course read culturally relevant and social justice articles that were specific to mathematics education (i.e., Gutstein, 2003; Leonard, Davis, & Sidler, 2005; Martin, 2003). The other teacher-researcher of this study, who did not have a teaching role in this study, shares a similar philosophy of education with Bridget and also promotes equity and social justice in publications, presentations, and in the classroom. This researcher teaches at a university in which the college of education promotes teaching from a social justice perspective as its core mission.

These courses provided a springboard to discuss issues of equity and social justice and to demonstrate pedagogical ways to infuse students' culture into lesson plans, particularly in mathematics. In both courses, teachers had to demonstrate teaching effectiveness by presenting a micro-teaching lesson (short 20-minute lesson focusing mainly on one concept as opposed to a full lesson plan) to their peers. In the pedagogy course, students could present a lesson dealing with any of the core content areas specific to their major field of study (English, mathematics, science, social studies) or specialty areas (art, music, physical education). For example, a student in the general pedagogy course read a book by Maya Angelou to integrate art and literacy. In the mathematics methods course, students focused on teaching a mathematics topic to students in grades PreK–8. An example of a lesson in the mathematics methods course consisted of using the faces of actors, such as Will Smith and Sandra Bullock, to teach about the Golden Ratio and symmetry. Both of the above lessons made broad connections to American culture. Micro-teaching to peers, however, does not provide preservice teachers with the field-experiences they need to teach. Learning to teach involves practice with real students. An important part of any teacher credential program is providing settings for prospective teachers to work with actual children (Ambrose, 2004; Ebby, 2000). Teacher interns, who were also students in Bridget's courses, had the privilege of not only delivering the content but also practicing culturally responsive pedagogy in urban settings in Philadelphia.

The Community-Based Sites

The teacher interns worked at two African American churches that had longstanding relationships in the communities they served. Both churches are located in urban neighborhoods in North Philadelphia. Both Zion and Haven churches have served the North Philadelphia community for more than 100 years. In the last 5 years, Zion collaborated with researchers at the university where the Math Links study took place by supporting preservice teachers' work with children in Saturday science programs (Leonard, Boakes, & Moore, in press; Leonard, Moore, & Spearman, 2007). Furthermore, Zion has served as a site for after-school and summer enrichments programs for early childhood and elementary students. In recent years, it became a site for an at-risk high school program supported by a grant from the city of Philadelphia. Haven, on the other hand, has not been as involved with educational endeavors. The recent addition of a computer lab and establishment of an after-school program has helped to thrust Haven into the community spotlight, however. Programs for children and adults have been developed. Because of their educational initiatives and community efforts, the Zion and Haven sites were selected for the eight graduate student participants in the Math Links study to obtain field-based experiences.

Five of these interns (one man and four women) worked at the Zion site during the fall of 2006. Three of these interns (two women and one man) worked at the Haven site during the spring of 2007. At-risk youth, 13 to 18 years of age, were enrolled at the Zion site. Children, 6 to 12 years of age, were enrolled in an after-school program at Haven. Thus, we were able to collect data on teacher interns' actions with elementary, middle, and high school students. It should be noted, however, that attendance at the two sites varied because both programs were relatively new and voluntary.

Methods

We used qualitative research methods to collect and analyze data in the Math Links pilot study. Because we report on two different cohorts of interns simultaneously, this study may be characterized as a study within a study. Specifically, we use case study methodology to analyze and report our findings. Case studies are often used for in-depth examination of processes that emerge from a small number of phenomena (Bogdan & Biklin, 1998). Considerations were given to ethnicity and gender to obtain a diverse sample for the case studies. Three of the teacher interns were selected for further study (one White man, one White woman, and one Asian woman) because their backgrounds provide the research community with rich data about the cultural sensitivity of teachers from these specific backgrounds. It is important to understand how these teachers enact culturally responsive pedagogy in urban settings. Whites, particularly White women, continue to choose teaching as a

career (Martin, 2007; Remillard, 2000). As a result, these teachers are more likely to work with urban students if African American and other teachers of color continue to decline. Data sources consisted of the following for each of the cases: coursework, informal observations at project sites, logs, and interviews. We then used the constant-comparative method to compare and contrast the cases (Glaser & Strauss, 1967). Each of the cases provided the researchers with rich data about the participants' development of pedagogical content knowledge in mathematics and culturally responsive pedagogy.

The results of this study will be presented in two parts. To answer the first research question about how the teacher-researchers' reform-based practices influenced teacher interns' beliefs about culturally responsive pedagogy, we analyze the results of structured interviews obtained from the teacher interns and classroom vignettes. To answer the second research question about how interactions in the community-based internship helped the interns to develop culturally responsive pedagogy, we analyze three case studies and examine one of these cases in depth. Due to data source limitations, these participants qualify as a convenience sample. While not appropriate practice for a quasi-experimental study, a convenience sample served our purposes for this pilot self-study to inform future research.

Procedures

Prior to serving as an intern, participants completed a 3-hour professional development session taught by a mathematics education consultant while they were simultaneously enrolled in one of Bridget's courses (as previously described). The teacher interns were trained to use *guided inquiry* during professional development. Windschitl (2003) characterizes guided inquiry by the level of student involvement. A hallmark of guided inquiry is that students investigate a prescribed problem using their own methods. While teaching the education courses, Bridget modeled inquiry-based instruction. Teacher interns also watched episodes of Kay Toliver as she engaged students of color in inquiry-based mathematics instruction (Foundations for the Advancements in Science and Education Productions [FASE], 1998). Thus, teacher interns were exposed to examples of inquiry-based instruction prior to working with students in the field.

To provide participants in this pilot study with field experience prior to student teaching, we placed them in settings where they could obtain 30 hours of fieldwork in informal education settings. The local churches sites were located within a one-mile radius of the College. Therefore, teacher interns could easily complete the required 30 hours over the course of the semester while simultaneously taking education courses. Seven teacher interns, who were enrolled in the graduate teacher credential program in the College (one of the original eight graduate teacher interns dropped out of the study due to a schedule conflict with her job), were observed by the teacher-researcher and/or the graduate research assistant as

they worked with students in the community-based settings during the fall 2006 and spring 2007 semesters.

The interns were required to keep a log of notes to document their activities with students each time they went to the site. These logs were analyzed by the researchers to determine not only how the teacher interns' pedagogy was changing but also how their attitudes toward the students were changing. In other words, we examined the logs for evidence of caring (Gay, 2000) and actions that exemplified behaviors that could be synonymous to having a culturally responsive or social justice stance (i.e., advocating for students when rules or regulations are unjust or unfair; teaching in a manner that informs students about the status quo and/or how to challenge such systems) (Gutstein, 2003; Tate, 1995).

An interview protocol was also developed and administered to participants after they completed their community-based field experiences. In particular, we were interested in comments that reflected changes in practices or attitudes about the student population. Teacher interns were given a four-digit ID number for identification purposes. The structured interviews were read and coded to categorize the teacher interns' responses. The teacher interns' responses were then analyzed to find themes and patterns among their experiences. Common elements informed the researchers about how to improve the field-based aspect of the project for future study.

Limitations

One limitation in this pilot study is the sparse number of student participants in the community-based field settings and the variant amounts of data collected from the teacher interns' logs. Some teacher interns wrote a minimal amount in their logs, while one in particular (a Korean woman) kept copious notes and detailed descriptions about the lessons and her interactions with students. Thus, these data sources are uneven. The interview protocol, however, was used to fill in gaps in the data. Thus, triangulation of data sources was used to increase the validity of our findings.

A second limitation is the instructor of the general education and mathematics methods courses in which the participants were enrolled was also a participant-observer in the study. While teacher-researcher is common in qualitative studies in education, issues of power and researcher bias are threats to internal reliability. To minimize these threats, a graduate research assistant was also a participant-observer in each of the field-based settings, and a second mathematics educator (the other teacher-researcher in this study), who had previously taught mathematics methods courses at the same institution and currently teaches mathematics methods courses at a different institution, corroborated the interpretation of data and the results. Thus, checks and balances were put into place to minimize bias and increase the integrity of our findings.

Results

Structured Interviews

Six of the seven teacher interns who participated in the community-based internship during the fall or spring semesters of 2006–2007 participated in the structured interview. Two reported on their experiences at Haven and four reported on their experiences at Zion. As shown in Appendix A, four categories emerged as a result of qualitative analysis: (1) Lessons learned from the program, (2) Teacher intern's perceived strengths, (3) Perspectives on the Math Links program, and (4) Perspectives on urban students.

Analysis of intern responses in lessons learned from the program (Category 1) reveal that three interns (2210, 0078, 1080) focused on classroom management issues (i.e., organized lessons, firm and consistent discipline, classroom management techniques) and three interns (3695, 9352, 0063) focused on care and/or relationships (i.e., diverse needs of children, building relationships, mutual respect, increased understanding of diverse students). Teacher interns reported perceived strengths (Category 2) by describing their commitment (0078, 9352), experience (3695), and lesson creativity (2210, 9352, 0063, 1080). Perspectives on the Math Links program (Category 3) reveal the interns at Haven (2210, 0078) did not believe they had the supervision and oversight they desired. One intern (9352) at Zion mentioned that organization and communication could have been better. However, teacher interns mentioned some of the benefits of the program, such as the resources (0078), exposure to work with students (2210, 3695, 0352, 0063, 1080), and learning from peers (0063). One intern (1080) who was student teaching at the same time that she participated in the study noted: "Activities presented to youth in the Math Links program were used the next day with students during student teaching." This comment highlights the importance of the teaching-learning process. One must actually engage in teaching in order to learn how to teach (Ambrose, 2004; Ebby, 2000). Finally, we analyzed the comments that emerged in Category 4: Perspectives on urban students. Three comments focused on students' behavior (0078, 0063) or opportunities (3695), but three commented on how their own attitudes and perceptions of urban students changed (2210, 9352, 1080). One intern at Haven remarked: "Children were intelligent, focused, and dynamic." One intern at Zion stated the program "challenged myths about urban students: lazy, don't want to learn; don't care about education; don't care about work. Students were hard working, wanted to learn, and wanted to understand math."

Because the College did not provide field-based experiences for graduate students prior to student teaching, the foregoing comments have important study implications. Overall, comments about urban students were consistently positive. Moreover, the community-based field experience allowed some of the teacher interns to become students of students and challenged negative perceptions and stere-

otypes about students of color (Nieto, 2002). In order to learn more about their interactions with students in the community-based settings, we present the case studies of three interns. Pseudonyms are used for anonymity. These cases are presented as vignettes.

The Vignettes

Although a total of 12 teacher interns participated in community-based field experiences in the 2006–2007 academic year, only eight were graduate students, which is the focus of this article. The profiles of these eight interns reveal two were White men and six were women (5 White and 1 Asian). Of these eight participants only six were also enrolled in one of Bridget's courses: 1 man; 5 women.

Vignette 1: Shawn. Shawn was a 25-year-old European American man with a sociology degree from the University of Michigan. Shawn was the only male teacher intern who worked at Zion. Because of this, many of the predominantly male students perceived him as a mentor. He was observed teaching an inquiry-based lesson that integrated mathematics and space science in the fall of 2006. The lesson involved having students calculate the percentages of different elements found in a sample of Playdoh used to simulate moon rock. Students learned how to slice the rock samples like geologists and then estimated and extrapolated the data to determine what type of rock sample they had by counting beads of different colors. The vignette taken from one of Shawn's reflection papers is presented:

> It seems as if my undergraduate education in sociology has laid the groundwork for a deeper and more applicable understanding of social justice and equity, which I have been able to build upon both in theory and in practice. Ultimately, my understanding of culture in mathematics education will be tested in the classroom, and that is why my experience at Zion this semester has been so valuable. While the context that children are raised in may not be the sole determining factor of their success, it undoubtedly will impact the rest of their lives. Students who have limited access to resources and effectual education will have limited opportunities to achieve success. This reality is clearer after one day at Zion than it could ever be in a journal article or textbook. Tutoring has become the ideal opportunity to apply what I am learning in the classroom to situations I will face as an educator. I am discovering that education, in particular my own, is a steady progression from abstract theory to more tangible concepts, concepts that have practical implications for the classroom. It is envisioning how to embrace the inquiry-based models of learning we are exposed to and relate them to every teaching opportunity we are presented with.

Shawn's vignette reveals the Math Links experience was pivotal to his development of critical consciousness and his understanding of equity and social justice as it related to mathematics education. Clearly, he exhibited culturally responsive pedagogy as he learned to mesh theory and practice. Shawn, however, hints at the complex nature of inquiry-based teaching. How do teachers relate the pedagogies

they learn in teacher education programs to students' lives? How do they include elements of student culture as a springboard for learning without watering down the curriculum or lowering expectations? These questions cannot be answered by participating in 30 contact hours of field experience. Nevertheless, Shawn had a better understanding of teaching diverse students after participating in the Math Links study.

Vignette 2: Camille. Camille was a 26-year-old European American woman who had received an undergraduate degree in English from Cornell University. She had also lived and studied abroad in Japan. She was an intern at the Haven site. During her observation in the spring of 2007, Bridget (recall this was the instructor and participant-observer) noticed that Camille had an excellent rapport with the 6 to 12 years old African American students. They were learning about the story of Sadako, Origami, and how to make paper cranes, which they connected together to make a long strand. Camille also brought pictures of her travels to Japan so the students could see the lifestyle of the Japanese people. Impressed by Camille's ability to retell Sadako's story, a Japanese girl's fight with Leukemia after being exposed to Agent Orange during World War II, Bridget loaned her the storybook by Coerr (1993). To help the African American students at Haven understand the gravity of Sadako's plight, Camille described an event that her students could relate to. The vignette taken from one of her reflection papers on social justice is presented:

> I would like to address what to me was one of the main strengths of this article [Leonard & Hill, 2008]. The background material regarding analytical scaffolding and social scaffolding is extremely helpful and profuse as is its later exemplification within the context of the [lesson]. The following discourse occurred during one of my own sessions with six African American students. My boyfriend, C, and I gave a joint presentation about the Blues (musically and historically) at the Haven after-school program where I tutored once a week.
>
> C [stated], "A contradiction is when you say one thing and then do another. The United States contradicted itself when it took away African American rights. Everybody, how would that make you feel?" "Sad," one said. "Unfair," said another. "Has anyone ever heard of the Blues?" I asked. Another student said, "It's when you are sad."
>
> C and I found that when we quizzed the students later on, they remembered almost word for word what was said. I had a very valuable first-hand experience with scaffolding and intend now, further confirmed by this article, to use it as often as possible in future lessons.

Camille's vignette reveals her ability to engage in culturally responsive pedagogy. She and her boyfriend engaged students by using their cultural capital to scaffold their learning. Camille's use of the Blues as social scaffolding shows her ability to move from theory to practice. The mathematics in this lesson was culturally relevant as she tried to link learning geometry and spatial skills to Sadako's life with cultural beliefs about her illness. To make connections with Sadako's story,

Camille used the Blues, which is a part of African American culture. By using the context of the Blues, the students were able to understand the affective nature of the story, and they were eager to make paper cranes and learn more about Japanese culture. Thus, Camille's lesson is an example of how to teach mathematics concepts within a social justice context.

Vignette 3: Sun-Lee. Sun-Lee was a 39-year-old Korean woman attending the College on a visa. She was a graduate of Ewha Woman's University in Seoul, Korea. She had an undergraduate degree in Library Science and was interested in teaching English to ESL students. Therefore, she chose to dually enroll in the TESOL and graduate certification program at the College. Sun-Lee taught and integrated science and mathematics lessons to high school students in the fall of 2006. She was instrumental in helping the students learn geometry, measurement, and aerodynamics by constructing kites (Leonard, 2002). Students made tetrahedral kites out of tissue paper, straws, and string (Center for Engineering Educational Outreach [CEEO], 2001). They learned mathematics vocabulary (tetrahedron, faces, vertices, edges, etc.), used rulers to measure accurately, and learned how lift, gravity, drag, and thrust worked together to make a kite fly. Sun-Lee kept a meticulous journal of her experiences at Zion. An excerpt from her journal describes her work with the students during the kite activity:

> There were three more girls, but I did not know their names yet. Since we had to reattach two bridles, we had to measure two strings for the two small kites. I thought that the students needed to find information from the text for themselves. When they asked me how to do [it], I read the instruction with them while pointing out the part. After reading, I asked them what it meant. For example, part of the instruction was for [a] three-quarter inch of space between the loop knot and the straw. Rickie showed me 3.4 inches by means of a ruler. Therefore, I pointed to this part of the instruction, and we read together. Rickie understood and made [a] three-quarter inch space. Carolyn said her ruler was not big enough to measure the longer part of a bridle. I asked her how she could measure the longer string. She thought about it and said, "Oh, moving like this." She displayed the iteration on the ruler.

Sun-Lee demonstrated structured inquiry in the foregoing excerpt (Windschitl, 2003). Rather than teaching by telling, she led one of the students to figure out the difference between 3.4 and ¾ inches and helped another student determine how to measure multiple pieces of string using a ruler. By helping them to construct their own knowledge, the students were more likely to remember the mathematics concepts they learned. This vignette hints at the complexity of the teaching-learning process. How much information should teachers tell students? How much should students be responsible for learning? Knowing "when to provide an explanation, when to model, when to ask the rather pointed questions…is delicate and uncertain" (Ball, 1993, p. 393).

The data presented above in Vignette 3 as well as data presented in the interview protocol show the unique characteristics and behaviors that Sun-Lee exhibited during the study. Moreover, the data she provided in her participant log provided rich accounts of her work with students at the Zion site. While she was selected because of convenience, the case of Sun-Lee provided the researchers with a deep and informative account of her field experiences at Zion.

The Case of Sun-Lee

The case of Sun-Lee was quite unique and interesting. She was the only person of color who participated in the Math Links study. Furthermore, she made tremendous strides in English fluency and literacy during the fall 2006 semester, and she became culturally competent as a result of her experience in the pilot study. Her participant log consisted of 13 detailed accounts of teaching and learning mathematics within a cross-curricular context at the Zion site from October 23, 2006 to December 13, 2006. Appendix B summarizes the lessons, teacher actions, student actions, and teacher behaviors.

Analysis of Sun-Lee's Case Study

Analyses of Sun-Lee's journal entries, as shown in Appendix B, reveal that she progressed rather quickly from using direct instruction to inquiry-based instruction over the course of the fall 2006 semester. On October 23rd, Sun-Lee used direct instruction to teach Andrew a part-whole interpretation of fractions and subsequently the conversion of those fractions into percents:

> I asked [Andrew] whether or not he knew how to get percentage. He said, "No." He got the 41 white rocks, 13 red rocks, and 7 blue rocks. In order to explain [how] the numbers could be transformed into numbers less than one, I helped him to draw a pie chart. We sectored the pie into 61 pieces. In the comparison of the pie with pizza, I explained 61 pieces as a whole number 1. And I told him that the concept could be expressed 7/61, 13/61, and 41/61, which were less than the number one.

On October 24th, Sun-Lee still wrote about "showing" students how to do things, but by October 25th, we have evidence that Sun-Lee began to use questioning techniques that allowed the students to develop their own understanding. Rather than teaching by telling, she was beginning to help students take responsibility for their own learning:

> I gave short instructions and wanted them to read the procedure again. I thought that the students needed to find the information from the text for themselves. When they asked me how to do it, I read the instructions with them. … After reading, I asked them what it meant.

By November 1st, Sun-Lee attempted to engage students in discussion. Yet, she was hesitant to do so because students' work was at different stages and because of her perceived limited English proficiency. However, a breakthrough occurred on November 2nd when Sun-Lee had two students offer their own examples of Newton's Third Law of Motion. By having the students experiment with a rocket launch from a lesson derived from *Mission Mathematics* (Hynes & Hicks, 2005) before introducing Newton's Third Law, students were able to make connections by collecting actual data and offering their own explanations of the law:

> "For every action there is an opposite and equal reaction." I gave an example with a ruler and the edge of the desk. By hitting the ruler with weak force, the ruler dropped down. However, the ruler flipped over and dropped down when I used strong force. Dante [used] a similar example. Also, Rickie [shared] his idea.

Toward the end of the semester Sun-Lee engaged students in investigations that led them to make discoveries about other theories as well. Mathematical probability was connected to genetics when Dante experimented with Punnett Squares using a coin to determine genetic outcomes. Finally, it can be seen that Sun-Lee realized that inquiry, although time consuming, is paramount to good instruction. At-risk students at Zion were engaged at high levels when they were given opportunities to investigate, discuss, and explain their reasoning. Analyses of Sun-Lee's journal show that she progressed over the course of the semester from using direct instruction to reform-based, context specific instruction. Most importantly, she empowered at-risk students by helping them to be self-directed and to take charge of their own learning, which is one of the tenets of culturally relevant pedagogy (Ladson-Billings, 1995).

Discussion

The results of this pilot study are promising. The major finding of the study is that during the graduate certification program five of the seven interns who participated in the pilot study, though older and more entrenched in their beliefs and values, engaged in reform-based practices during the internship. Evidence for this claim is supported by the results of interview data and case studies. This finding has important implications for the field if these changes can also occur among beginning teachers. It is consistent with the finding by Osisioma and Moscovici (2008) in which they observed a shift in science teacher interns' beliefs from traditional methods of teaching science to an inquiry and reform-based approach about teaching and learning over the course of two semesters. Data, such as that published by the National Association of Educational Progress (NAEP), continue to show dismal performance in mathematics, particularly in grade eight (National Center for Educa-

tional Statistics [NCES], 2007). The ability to think and reason is critical if one is to achieve above basic and proficient levels in mathematics.

A second finding is five of seven teacher interns who participated in the community-based internship changed their perceptions of the predominantly African American students participating in the Math Links program. They recognized that "typical" stereotypes about these children simply were not true. The students were eager and willing to learn mathematics and were receptive to one-on-one tutoring and whole group instruction. Furthermore, these interns developed an ethic of care and exhibited teacher dispositions that Martin (2007) characterized as racial competence and commitment to anti-oppressive and anti-racist teaching. Nevertheless, additional studies are needed to learn whether the perception of hard work and the ethic of care might be transported into the traditional school setting.

A third finding is the importance of providing teacher interns at the graduate level with field-based experiences prior to student teaching. Because this population generally enrolled in evening courses at the College to obtain a teaching certificate, field experience was not a part of the credential program. Five of the six teacher interns interviewed noted the value of the field experience. One specifically mentioned how she used materials and techniques learned in the Math Links program during student teaching. The community-based internship provided these interns with an opportunity to learn from their interactions with students. This finding concurs with the findings of our previous work with teacher interns (Leonard, Boakes, & Moore, in press) and with Ebby's (2000) work with preservice mathematics teachers. Prospective teachers' pedagogical content knowledge in mathematics was dependent upon the teaching-learning process (Ebby, 2000; Sherin, 2002). Additional research, however, is needed to learn whether inquiry-based practices learned during fieldwork can be sustained throughout induction.

Finally, this pilot study has implications for researchers attempting to link the teaching of mathematics to social justice. Teaching preservice and beginning teachers about social justice in a vacuum was not meaningful, as two interns who participated in the case studies attested. Actually working with students whose lives stood in stark contrast to their own privileged backgrounds was eye opening for these two interns. They realized firsthand the powerful impact poverty has on some urban students' lives and the ramifications of the lack of educational opportunity. Moreover, the structured interviews and case studies show how several teacher interns were moved by the potential (realized and unrealized) of students in the community-based programs. Thus, learning to teach for social justice must include critical work with appropriate student populations.

The results of the Math Links pilot study show that providing community-based field experiences for teacher interns benefits both interns and students alike as relationships and rapport are forged during the mentoring process. Not only did one of the interns continue for an additional semester but also site coordinators and

students requested additional interns the next semester. Given limited research dollars, sustaining successful partnerships are challenging. However, the Math Links study shows the educational possibilities when there is a nexus between research communities and civic responsibility.

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Appendix A

Comparison and Contrast of Teacher Interns' Responses to Interview Protocol

Teacher ID/Setting	Lessons Learned from Program	Teacher Intern's Perceived Strengths	Perspectives of Math Links Program	Perspectives of Urban Student
2210 Haven	Learned that highly organized lessons that allow some flexibility are important; discipline needs to be firm/consistent.	Used background knowledge in art and history to blend a variety of media and context to lessons, which maintained student interest regardless of learning styles.	Prior teaching experience was limited so extra exposure was helpful. Program allowed me to work one-on-one with children. Little structure and guidance provided, which caused site director to have some uncertainty about the parameters of the program.	Children were intelligent, focused, and dynamic. Struck by how poverty and family situation can undermine intelligent students, causing them to miss school and jeopardize their education. Longed to exert more influence on parents when she becomes a full-time teacher.
0078 Haven	Variety of resources available to teachers. Classroom management techniques.	Commitment to teaching urban children.	Provided resources. More training and oversight needed.	Broader view of behavior issues.
3695 Zion	Learned about the diverse needs of children.	Possessed patience and caring qualities; Had prior experience working with Pre-K inner city children.	Children have different needs; teacher must cater to the needs of all children; provided experiences beyond private and suburban settings.	Program provided opportunities for children.
9352 Zion	Building relationships with children is important. Mutual respect between teacher and students is key to academic success. Consistency is vital with students.	Personal creativity came out during the internship. Made connections with students despite differences in age and appearance. Had prior experience teaching high school. Commitment to working with children who have special needs.	Wonderful experience that exposed the intern to real-world setting and allowed her to build confidence. Program provided opportunities to interact with students in an informal way. Organization and communication could have been better. Requested lesson templates or exact lesson plans to follow.	Program helped intern to become a better teacher by overcoming misconceptions and insecurities about teaching youth. Learned how accepting students can be when given special attention.
0063 Zion	Hands-on lessons can serve as motivator. Increased understanding of the similarities/ differences between child in U.S. and Korea.	Constructing hands-on lessons; ability to adapt what I learn to new situations.	Providing the opportunity to observe students' learning and to learn from peers and mentors. Hands-on activities provided learning opportunities for the students.	Worried about student motivation and attentiveness, but it changed. Older students responded well to hands-on activities and were highly engaged in learning.
1080 Zion	Learned how to control the pace of the lesson and make sure students are on task. Learned how to use appropriate classroom management techniques.	Discovered ways to motivate students; one-on-one interaction led to direct involvement in one case.	Program allowed intern to tutor students in a small groups; experience allowed her to develop ideas for use in other settings. Activities presented to youth in the Math Links program were used the next day with students during student teaching.	Program challenged myths about urban students: lazy, don't want to learn; don't care about education; can't do the work. Students were hardworking, wanted to learn, wanted to understand math.

Appendix B

Journal Analysis of One Teacher Intern's Pedagogy

Date and Lesson Type	Teacher Actions	Student Actions	Analysis of Teacher Behaviors
October 23, 2006 Rock Doctors Students cross cut Playdoh representation of Moon Rocks to determine what type of rock they had by the percentages of minerals they found in the Playdoh.	I asked [Andrew] whether or not he knew how to get percentage. He said, "No." He got the 41 white rocks, 13 red rocks, and 7 blue rocks. In order to explain the numbers could be transformed into numbers less than one, I helped him to draw a pie chart. We sectored the pie into 61 pieces. In the comparison of the pie with pizza, I explained 61 pieces as a whole number 1. And I told him that the concept could be expressed 7/61, 13/61, and 41/61, which were less than the number one. By writing down the numbers in the format, I modeled how to compute the division 7/61.	Andrew computed the other fractions. Anthony brought his multiplication knowledge to divide the fractions.	Sun-Lee worked one-on-one with Andrew. She uses direct instruction to help him understand parts of a whole and to teach how to calculate percentages.
October 24, 2006 Tetrahedral Kite Students used straws, string, and tissue paper to make tetrahedral kites. Each student made one cell, and all of the cells were put together to make one large kite.	Since Joshua said, "I don't know how to put these straws," I approached to help him. He was holding his sixth straw, which needed to support the tetrahedron. I showed how the straw could uphold the tetrahedron and said to him to run the thread through the straw and clip tightly.	The runner and holder took their positions while releasing the string to fly it. The runner and the holder tried several times, but it didn't work out. The kite kept falling down whenever the holder let go, although we changed the position of the bridle.	Sun-Lee worked one-on-one with Joshua. She supported his learning by helping him make one tetrahedral cell for the kite.

October 25, 2006 Tetrahedral Kite (cont.) Students redesigned the tetrahedral kite.	We started taking the kite apart. While making the knots, I looked for additional help. I called Carolyn…. Since we had to reattach two bridles, we had to measure two strings for the two small kites. I gave short instructions and wanted them to read the procedure again. I thought that the students needed to find the information from the text for themselves. When they asked me how to do it, I read the instructions with them…. After reading, I asked them what it meant. Since we had two different kites, I suggested two groups of students pull each kite….The reason was their own experience of pulling the kite will make them think in depth.	Students suggested modifying the kite: place wax paper on the open cells, change position of bridle, move to larger space to fly the kite. Rickie said he could make a new small kite. Andrew and Joshua flew the kites, and it stayed horizontal while the students were running. They were running all over the place, and it did not go up vertically.	In this lesson, Sun-Lee employs some inquiry-based practices. She allowed the students to have some autonomy and encouraged them to find out information for themselves and to think in depth about how the kite flew.
November 1, 2006 Alka Rockets Students used Fuji film canisters and index cards to make a rocket. After making predictions, students used different amounts of Alka-seltzer and water into it to launch the rockets. They measured the height each time the rockets were launched.	I told the students to check whether they had all the items [for] the procedure. Also, I show two rocket pictures that I printed in color from the Internet to talk about the force and direction of…the rockets. Students were asked to read the first procedure. By referring to the procedure, I intended to enable students to practice applying necessary information to their own work. I asked what the function of the rocket fins and nose cones were. The discussion could not develop well partly because each student was working on a different stage. The other reason could be that I was not confident to lead the discussion because I was concerned about my English proficiency. Although I understood preparation and practice in real classrooms could have reduced my anxiety, the anxiety in my mind still existed. If I use the lesson again, I will have the students read through the procedure first to grasp the whole process. Also, they could discuss the functions of the fins and cones more than they did this time.	The students completed their rockets and were [asked] to predict the height. A table was given to record each height. Each student tried the initial variable (amount of water). The rockers went high up from the scale of 2 to 8. While trying the other variables (size of tablet). Students figured out that the less amount of water and more amount of Alka-Seltzer went higher than the others. The lesson was a success. Marie said it was the most interesting experiment. Rickie said, "It was pretty cool."	Analysis of lesson reveals Sun-Lee continues to utilize some aspects of inquiry. Instead of teaching by telling, she wanted students to find the information and apply the knowledge learned to the task of making the Alka Rocket. Although she was ambivalent about her English, she tried to lead the students in a discussion about how the fins and nose cones would impact the rocket's flight. While she was not able to engage students in such a discussion at this juncture, Sun-Lee reflected about how she could do a better job the next time she taught the lesson.

November 2, 2006 Alka Rockets (cont.) Followed up with data analysis of the results from previous day's launch.	I asked…how many inches are in a foot? Some said 6 inches because they knew that the temporary ruler was…six inches. Someone said 12 inches. I wrote 1 foot = 12 inches to help students transform inches to feet. After the measurements, I told them the experiment proves Newton's Third Law of Motion: "For every action there is an opposite and equal reaction." I gave an example with a ruler and the edge of the desk. By hitting the ruler with weak force, the ruler dropped down. However, the ruler flipped over and dropped down when I used strong force. Dante [used] a similar example. Also, Rickie [shared] his idea.	Students recalled their highest results and discussed the influential factors for the highest rockets. Everybody said that less water caused the rockets to go higher. They figured out the real lengths by measuring the heights and multiplying their results by six inches because the temporary ruler was segmented every six inches. Dante thought one scale of the temporary ruler was a foot. So he wrote his rocket went, 6 ft., 8 ft., and 7 ft. But after the explanation, he changed 6 to 36 inches and 8 to 48 inches.	Sun-Lee probed the students to determine their background knowledge on measurement. They knew 12 inches was one foot but the data reveal little experience with measurement tasks, scaling, and converting inches to feet. While Sun-Lee reinforced equations and laws to help students understand the activity, she also demonstrated Newton's Law. This demonstration led two students to share examples and ideas about Newton's Law, that is, the students offered alternative explanations, which is a hallmark of inquiry.
November 15, 2006 Genetics and Punnet Squares Student used probability and Punnett squares to make predicts about traits	While leaving the classroom, I thought it would be better for us to go over the Punnett square tomorrow because I felt that [Dante] was not sure yet.	In order to decide the components of genetic trait, students were asked to flip a coin. When Dante flipped a nickel twice, he got a pair of N and n genes for each flip. That means his portrait has a round nose, which carried a recessive gene of a pointy nose. After deciding all other traits including the color of eyes and hair, he drew the portrait with color[ed] pens. Students were asked to apply the rule to real life problems. Dante created the Punnett square but got 2 squares wrong.	Sun-Lee worked one-on-one with Dante as he determined genetic traits and used the Punnett square. Realizing his struggle with the Punnett square, Sun-Lee planned to review concepts with him the next day.
December 1, 2006 Measurement Students learned customary and metric units of length.	In a previous lesson, Alka Rockets activity, Dante used the unit of length (3 ft., 8 in.) to record the measurement. Dante uses the unit consistently [sic] in the right form, but I wanted to know whether or not he was aware of inches, square inches, and square feet. When I asked him to explain…the relationship between a meter and a yard, he did not explain, he draw [sic] a division calculation. How could I let him know the relationship between a meter and a yard? Step by step! I asked Dante to show and explain his thoughts a lot because I learned that teachers should ask students, "Explain what you think." However, this process takes time. In a real class with many students, it would not be easy to follow each student's thought process.	Dante recognized an inch and said [to] himself the ruler was a foot when he saw the ruler. He measured a line of 3 inches on his own. When he measured 2 1/8, he asked [Sun-Lee] how to measure. (A book was provided for a reference.) He measured a yard and a meter of the table again by using the paper ruler. [He measured] a meter length with the paper inch ruler. He got 39 5/16 inches. Also, he measured one yard with the paper centimeter rule. He got 91 cm. Then, he referred to the conversion table and found that one meter is 100 centimeters. Now, he could understand one yard is 90% of a one meter.	During methods class, Sun-Lee watched the movie *Stand and Deliver*. In the film, Jaime Escalante helped his students learn calculus by teaching them step by step. Sun-Lee borrowed this phrase and helped Dante develop mathematical knowledge by providing hands-on experiences with paper inch and centimeter rulers. She also learned the importance of allowing students to explain their thinking from the methods course. However, she was also aware of the challenges teachers face when they try to use the method in regular classrooms.