

TEACHERS AS INTERNS IN INFORMAL MATHEMATICS RESEARCH

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This study reports on teacher-interns' observations of research sessions involving urban students participating as subjects in an informal mathematical learning after-school program. The research comes from a project that investigates how minority students from low-income, urban community build mathematical ideas and engage in mathematical reasoning. Videotape data from debriefing sessions of the research team, including teacher interns, show that teacher-interns attend to the behavioural and cognitive aspects of the students' mathematical activity as well as the research interventions.

INTRODUCTION

The purpose of this research is to describe patterns of teacher-interns' observations of research sessions involving sixth-grade students engaged in well-defined, open-ended mathematical tasks in fractions, combinatorics and probability, over a 6-month period. The research is an outgrowth of a study, known as the Informal Mathematical Learning project (IML) and funded by the National Science Foundation (NSF award REC-0309062), which investigates how minority students build mathematical ideas, engage in and articulate their mathematical reasoning in the context of an after-school mathematics program. The IML research takes place in Plainfield school district, a low income-urban community whose school population is 98% African American and Latino students. The 9-member team of teacher interns includes elementary and middle-school teachers of the district. During the IML sessions, groups of 2 or 3 teacher interns took ethnographic notes of small group of students working on mathematical tasks. This study reports on such observations. Four research questions guided this study: (1) what behaviours of students did the teacher interns attend to? (2) What evidence, if any, is there that the teacher interns attended to students building of mathematical ideas reasoning? (3) What evidence, if any, is there that the teacher interns attended to the researchers' interventions? (4) What evidence, if any, is there that the teacher-interns' observations varied over time? The general approach was to provide the teacher interns with the opportunity to decide what issues about the IML sessions stood out for them and how they wished to articulate them. However, given the focus of the IML project, there was a special interest in the teacher-interns' observations about the students' mathematical reasoning. It turned out, as described in this study, that the teacher-interns' observations were broader in scope. They included also observations of the students' behavioural and research interventions and varied over time. It may be worth mentioning that, the teacher-interns were more than just observers in the IML project. They also provided

important contributions to the on-going research decision-making that helped plan subsequent research sessions. Their observations and teaching experience were useful in designing new seating arrangements for the students, new activities, and providing effective ways of dealing with the students, which helped increase student engagement and productivity.

THEORETICAL FRAMEWORK

According to the discussion document for ICMI study 15, the teachers' role in promoting students' learning is no longer being overlooked or taken for granted. There is a growing awareness that no effort to improve students' learning can succeed without a parallel effort to improve teachers' learning. Research on teacher education has been also expanding rapidly. However, the document recognizes that much more remains to be known about teaching and research on teaching. In particular, it calls for more research on "the knowledge, skills, personal qualities and sensibilities that mathematics teaching entails, and about how such professional resources are acquired (p. 3)." Another area of need is a study of teaching in particular [socio, cultural] contexts. Cohen and Ball (1999) identified two main reasons for the failure of research programs that were based on the "building of instructional capacity" in promoting lasting or even "detectable" improvements in schools. One reason is the use of methodological approaches that are not comprehensive enough to capture the "complex social organizations" that schools often represent. In particular, they claim that, if any teacher development program is to be successful, it must examine the triangle involving students, teachers and class material in an interrelated rather than isolated fashion. The other reason is that most improvement programs do not provide "opportunities for teachers' learning that would be needed to change classroom instruction (p. 1)." In particular, they argue that teachers need to be offered opportunities to learn more about not only the content that they are supposed to teach, but also, and most importantly, about "about how students think about that content (p. 1)." Similarly, Maher (1987), Martino and Maher (1999) and Wood (2004) emphasize the importance of teachers attending to students' mathematical thinking, as they pursue teaching approaches that promote learning in classrooms. Finally, Putnam and Borko (2000) focus particularly on actual professional development programs. They argue that the best models of teacher professional development combine workshops that introduce research-based ideas with on-going support. Such an approach requires the development of teachers as communities of learners who are enculturated into new practices and ways of thinking, which takes time, trust and support to develop (Grossman, Wineburg & Woolworth, 2001; Sherin & Han, 2004). For instance, Sherin and Han studied the effectiveness of video clubs, where groups of teachers come together to discuss video segments of their practice in mathematics teachers professional development programs. They found that through a year of in-depth analysis of videos of their practice, the main focus on teachers' discussions shifted from teacher actions to increasingly in-depth analysis of student thinking.

The design and implementation of this study builds on key theoretical issues discussed above. In particular, given the research its focus, the IML project provided the teacher interns with research-supported learning opportunities on students' mathematical thinking and access to research interventions that could be potentially modelled into classroom pedagogical interventions. The research uses a fairly comprehensive approach, extending the triangle of students, teachers and class material to include also researchers. Finally, similar studies (Beswick, 2004; Siemon, Virgona, Lasso, Parsons & Cathcart, 2004) suggest that examining practicing teachers' observations of teaching experiences, over time, is an important way of influencing teacher practice and a useful mechanism for teachers to reflect on their practice.

METHODOLOGY

This study relies on videotaped observation reports of nine teacher interns who participated regularly in the classroom-based research sessions of the IML project. The reports were collected during 1-hour long debriefing sessions that were held immediately after each research session. Fourteen debriefing sessions constitute the data for this study and correspond to an equal number of research sessions held during the 6 months of IML project. The analysis of the videotapes of the debriefing sessions followed data treatment procedures recommended for videodata (Powell, Francisco & Maher, 2003; Erikson, 1992) and qualitative phenomenological research (Moustakas, 1994; Giorgi, 1985). Seven analytical procedures were used. First, each session was watched entirely to have a sense of its content as a whole. Second, each session was partitioned into segments identified by particular issues being reported. Third, each issue and segment were described in as much detail as possible. Fourth, the issues were scrutinized and significant or critical issues selected on the basis of their significance to the research questions. The fifth and sixth procedure aimed at characterizing the significance of the issues. The fifth procedure involved transcribing entire the segments corresponding to the critical issues. In the sixth procedure, narratives were written that described the significance, or insight, of the issues. Finally, the seventh procedure involved a structural analysis across the fourteen debriefing sessions to identify emerging categories for the entire data set. The characterization of the categories constitutes the teacher-interns' observation described in this study.

RESULTS

The teacher-interns' observations of the IML research sessions can be summarized in three main categories, referring to teacher-interns' observations of the students' behaviour, students' mathematical reasoning and of research interventions, respectively. The categories and the main issues raised by the teacher interns are presented in the table shown below and discussed in the next three sub-sections. Due to limitation in space, supporting excerpts are provided for only some the issues.

Students' behaviour	Students' reasoning	Research interventions
Discipline	Language	Tasks design
Group dynamics	Strategies	Closure
Engagement	Confidence	Withholding answers
Rapport	Meaning	Justification
	Novel ideas	

Students' behaviour

The teacher-interns' observations of the students' behaviour focused on discipline, group dynamic, engagement issues and rapport between students and researchers and among themselves. The rapport issue is discussed in the sections on observations about mathematical reasoning. A few major patterns can be distinguished. First, in a particular debriefing session, the teacher interns almost invariably reported about behavioural issues before making observations about the students' mathematical thinking or research interventions. Second, over time, the teacher interns made fewer and fewer observations about the students' behaviour, as the observations focused more and more on the students' mathematical reasoning. Third, reports about the students' engagement in the tasks were more predominant. As result, the teacher-interns' reports suggested potentially interesting insights regarding students' motivation to do mathematics. In particular, students reportedly tended to enjoy working some problems more than they liked working on others. This suggests a task-dependent type of motivation. The teacher interns also reported observing that some students showed signs of frustration for not being able to express their mathematical ideas and reasoning, particularly in ways that some of the researchers could understand them. The teacher-interns argued that this was particularly the case in the early stages of the program. Interestingly, however, the teacher interns noticed, below, that the language of the students grew increasingly more sophisticated over time. Competition among students was also mentioned as a disruptive aspect group dynamics, which resulted in a diminished engagement in mathematical tasks by some students. Finally, motivation was related to two specific research interventions. In one, some teacher interns reported cases of students whose lack of involvement could be attributed to research sessions dwelling for so long on the same tasks. The students did not necessarily solve the tasks successfully, but reportedly showed sign signs of boredom after working on the same task for too long. The other research intervention related motivational issue follows from the excerpt below:

Teacher Intern 1: Herman was getting frustrated with Robert [research facilitator] because he kept asking "This opposite. I don't understand this opposite." And then after a while, I think he [Herman] really turned off, and then Robert moved on to Dante to see if he could get something out of him because Herman wasn't getting it.

The excerpt suggests that frustration may be the result of intense interviewing that does not provide time for students to think and organize their ideas.

Students' mathematical reasoning

The teacher-interns' observations on the students' mathematical focused on five major issues. Overall, the teacher-interns reported observing that, over time, the students' mathematical reasoning grew increasingly more sophisticated. The teacher interns explained the idea in a number of ways. First, the teacher interns reported that the language of the students became more sophisticated, as the students' vocabulary started to include the names of and the mathematical concepts involved in the tasks they were assigned to work on. Second, the teacher interns reported cases in which they had been surprised or amazed at the strategies used by the students to solve particular problems. Third, the following excerpt suggests that the rapport between teachers and students and among students improved. Most importantly, however, it also suggests that students became intellectually more independent learners:

Teacher Intern 2: I spent the last week looking at a November CD [CD tape with students work in November]. I walked around in today expecting Cuisenaire rods [the students had worked on fraction activities involving cuisenaire rods], and I was really taken aback by the level of sophistication. There is something coming from them that's kind of saying to me, "You know, a problem is worth putting time in. It's worth thinking about." And that's a lot of growth from the beginning, when they kind of looked at us like, "What do we want them to do?" Okay, I see a lot of growing going on, a lot of socializing going on. They're more comfortable, around each other. They are more comfortable with us. I think a lot of genuine personalities are beginning to shine through, and that's okay, because that's part of what they have to learn right now. I really enjoyed it today.

Fourth, the teacher interns reported noticing the students' concern for meaning and, in particular, personally meaningful ideas and ways of expressing them. In the excerpt below, Teacher Intern 3 reports attempts by the students to develop their own idea of what counts as a convincing argument, as they debated whether or not a diagram or picture should also include a text to count as a convincing argument:

Teacher Interns 3: From listening to them, basically posting out, they developed an unspoken rubric to determine what is needed to make this a convincing piece of work. One group stated that the diagrams are fine but there is no text to support the diagram. And then there's text without support for my diagram. So, it seems as if like teachers we use the specific rubric to follow certain things. The students have developed upon themselves the specific "rue-brick" to determine what is convincing or not convincing.

Fifth, the mathematical behaviour of the students supposedly became more sophisticated also as a result of the students starting to take up the mathematical behaviours of mathematicians and researchers. This was particularly the case regarding the concern in mathematical for not accepting mathematical statements without a proof:

Teacher Intern 4: Some of the discussion was very detailed. It wasn't frivolous discussion. Like "I don't like this just because I [inaudible]. They were, really, acting, well, they were real mathematicians. Walking around, I was impressed to see the interaction and even the communication among themselves. Within the groups they conversed about what was missing, they asked each other, "Are you convinced?" "Where are you convinced?" or "Why or why not?" And they kept on trying to get more specific. So, I thought the conversation were really good, on point.

Finally, it may be worth mentioning that some teacher interns reported learning new ideas from observing the students working on particular tasks. For instance, Teacher Intern 5 below marvels at and admits never seeing before the strategy a particular student used to solve a mathematics problem, which involved finding all 4-tall towers that could be built when choosing from two colours, yellow and blue:

Teacher Intern 5: I had never seen anyone do it quite that way. Whenever we've done this with a group of teachers or adults, and then he did the other one, and then he noticed the pattern at first, and he might have had it, but I just don't know where to go with it, but he was like, "uh" counting on the top, "yellow, blue, yellow, yellow, blue, two blues" and I think that's the way it went. He knew exactly how it placed them and I thought that was interesting

Research interventions

Some of the issues that the teacher interns attended regarding researcher interventions are already reported above. One is Teacher Intern 3's observation that students seemed to take up researchers' investigative roles. Other insights on the teacher-interns' observations of research roles follow from the four issues mentioned in the table above. Two observations on research interventions are closely related to the claim above by some students seemed to get frustrated with intensive interviewing that did not allow them time to think about the mathematical activity. The two observations concern closure and tasks design. More specifically, regarding the appropriate research intervention to deal with the issue above, some teacher interns took notice of the advantages of avoiding forcing closure and of introducing new problems, which, by design, were extensions of previous problems. However, the teacher interns highlighted the importance of two specific research interventions. First, one teacher-intern reported noticing and reiterated the importance of withholding answers from students and, instead, encouraging them to rely on their

thinking, either individually or as a group. In particular, teacher Intern 6 suggests that such an intervention enhances intellectual independence in students:

Teacher Intern 6: One of the things I like about your [the leading researcher's] idea, by the way, is that you are saying that you don't need an authority to figure out if what you've done is right or wrong. It can come from you, and boy, that's a lot of empowerment. That's very special.

The research intervention noticed and supported the teacher interns is the importance of justification of students justifying their answers or mathematical arguments, as part of their normal students' mathematical activity:

Teacher Intern 7: In terms of where, in my opinion, to go next, I do agree that they may feel like "I am finished with it" but the idea of the justification, I think, is really, important for them to see what it looks like. Because we have this issue in the elementary school where I will, you know, give kids an open-ended question and they'll give me an answer and I will write on the paper, "Can you prove it to me?" and fourth-graders will say, "Well, what do you mean by that? They really don't understand that. So, I'm sure kids who are coming into sixth grade have really not had that many experiences. So, if we show them some models of what justification looks like, they'll have a sense of "Oh, this is what you mean." You know, it's not just drawing what I've built; it's also trying to talk about what my thought process is in how I'm determining that I have everything

It may be worth mentioning that the teacher-interns' debriefing reports suggested that that much of the teaching in their schools was based on teachers showing and telling students what to do and did not emphasize justification of mathematical arguments.

CONCLUSIONS

The results of this study provide evidence for the claim that carefully designed professional development programs can help teachers appreciate the importance of attending to students' mathematical thinking. The sophistication of the teacher-interns' observations is evident in the content of their observations and in the comprehensive approach used, which relates observations about mathematical reasoning to observations about behaviour and researcher [pedagogical] interventions. The results are consistent with findings from similar studies discussed above. The teacher interns relate their teaching experiences in schools to their observations (see excerpt from teacher Interns 7). This is consistent with studies (Beswick, 2004; Siemon et al. 2004), which show that teachers' observations of teaching experiences, over time, influences their practice and is a useful mechanism for them to reflect on it. The teacher interns' observations also evolved from a focus on behavioural issues to more detailed accounts of the students' mathematical thinking. This also supports the findings by Sherin and Han (2004) described above. Finally, the results of this study provide evidence of the advantages of research-

supported longitudinal teacher professional development programs, particularly those that examine simultaneously teaching and learning.

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