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"Numbers Always Make Sense": Janie's Experience of Learning to Teach Elementary Mathematics

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In order to provide pre-service teachers with rich contexts for learning to teach mathematics, teacher education programs usually combine a mathematics methods course with clinical teaching experiences. This paper explores a student-teacher's experience of learning to teach mathematics by observing one mathematics methods course she was enrolled in and her actual classroom teaching. In particular, this ethnographic case study examines how the student-teacher understands and applies messages from the methods course to her teaching practices. Some differences emerge with regard to ideas and practices. The underlying factors for explaining the gaps are discussed. Finally, this paper provides some implications for pre-service teacher education.

I. INTRODUCTION

The current reform movement in mathematics education has initiated an ambitious agenda of teaching mathematics for understanding (NCTM 1989; 1991; 2000). However, learning to teach mathematics for understanding is very difficult especially for pre-service teachers who have learned mathematics as a set of rules from their schooling. Despite their eagerness and willingness to teach differently, their actual teaching methods often remain unchanged (Ball 1993; Cohen 1990; Schifter & Fosnot 1993).

Mathematics methods courses[1] in teacher education programs play an important role for pre-service teachers to develop their instructional practices. For instance, McDermott, Gormley, Rothenberg & Hammer (1995) report the positive influence of methods courses integrated with classroom teaching experience on pre-service teachers' understanding of

[1] Mathematics methods courses refer to general courses in which pre-service teachers learn structures of mathematical disciplines as well as strategies, techniques, basic rationales, and materials for teaching in elementary school

teaching. Hill (1997) suggests that pre-service elementary teachers can learn to teach for relational understanding (Skemp 1989) by reflecting on the connections of learning theories to their field experience. Philippou and Christou (1998) show the sig-nificant improvement of prospective teacher's attitudes towards mathematics, particularly regarding satisfaction from and the usefulness of mathematics. The learning-to-teach context is crucial to student-teachers.

Despite these encouraging indicators, there is daunting body of evidence that the influence of teacher education programs may be relatively weak. Ball (1990) found that prospective teachers' conception of mathematics as a set of rules is notoriously resilient. Borko, Eisenhart, Brown, Underhill, Jones & Agard (1992) claim that mathematics methods courses often fail to lead pre-service teachers to reconsider their mathematical knowledge base or their beliefs about teaching mathematics. They found that lack of consistency between methods courses and cooperative schools tends to lead student-teachers to adopt the procedural methods of the latter. Even student-teachers whose personal beliefs are compatible with the reform recommendations often experience difficulties in focusing on children's conceptual understanding when they encounter complexities at the classroom situation (Raymond 1997; Rust 1994).

This paper explores the influence of a reform-oriented methods course by observing one student-teacher's actual math teaching at an elementary school. Inconsistency of her ideas and practices reflects how the student-teacher implements the messages about math teaching from the methods course. Her teaching reveals complexities which make it hard to teach mathematics for understanding. This paper explores the underlying factors for such complexities by looking inward in terms of her knowledge and views, and by looking outward in terms of key factors in her environment. This paper ends with some implications for pre-service teacher education.

II. METHOD

This study used the method of participant observation (Spradley 1980). This ethnography inquired into the process of a student-teacher's learning to teach mathematics, as she took a mathematics methods course offered at a major university in Louisiana in the United States. The instructor of a mathematics methods course for prospective elementary school teachers recommended Janie[2]. Because Janie already had two-years of teaching experience as a non-certified teacher, it was of great interest to look at how she might apply the messages from the methods course to her actual classroom teaching situation.

[2] The name of teachers and students in this paper are pseudonyms.

I observed each session of the mathematics methods course during a spring semester (January to May). The class lasted for two hours once per week. In addition to audiotaping the lessons, I took field-notes which included general classroom activities, main messages from the instructor, students' participation structure, etc. The broad descriptive observations were used to characterize the general orientation of the methods course. I collected whatever materials were distributed in the course, trying to get an overview of the course. I also looked at Janie's papers (with her permission) submitted as a part of class requirement, attempting to understand her views with regard to teaching mathematics.

The methods course required field experience by which the student-teachers work together in pairs in an assigned classroom. Janie's peer partner, Jill, had no teaching experience. After the methods classes, Janie and Jill sometimes discussed their collaborative teaching in Janie's classroom. I observed these brief discussions and took notes.

I observed Janie's mathematics teaching once per week for two hours or so during the semester. At first, I made broad descriptive observations to get an overview of the classroom situation. I took field-notes in her classroom to describe the general classroom atmosphere, lesson structure, students' participation, my immediate reactions, etc. Starting at the third visit, I audiotaped the lessons. Reviewing the field-notes and audiotapes led to more focused observations by which I investigated the difficulties Janie encountered in the process of learning to teach mathematics.

As my observation became familiar to Janie and her students, I additionally videotaped five lessons. The videotaped lessons were extensively reviewed, and then partly transcribed to be used as empirical evidence for this study. Sometimes, notably in the early phase of this study, Janie asked me to help her prepare some teaching materials, check students' worksheets, and monitor students' activities in small groups. I, as a participant observer, engaged in such activities that seemed appropriate to the classroom situation.

In addition to the classroom observations, during the latter part of the semester I had a total of three-hour audiotaped interviews with Janie focusing on her beliefs about mathematics and its teaching. I postponed these interviews to the latter phase of the study in order to better understand her classroom teaching practices, without allowing Janie's professed perspectives to shape my interpretation of her teaching. The specific interview questions came out of an initial analysis of the classroom observations. The interviews in turn provided useful background information to understand Janie's teaching practices.

During the latter part of the semester, I also interviewed Jill to gain her perspectives on Janie's teaching practices. Since Jill was familiar with Janie's teaching, her perspectives were particularly helpful to judge whether my understanding of Janie's teaching practices is appropriate at a global level.

III. FINDINGS

The mathematics methods course and Janie's own classroom were the two major contexts in her learning to teach mathematics. First, I describe the general characteristics of the two contexts. Then I examine Janie's classroom teaching practices with respect to the influence of the methods course. Finally, I analyze a range of significant factors, which shape her teaching practices.

3. 1. The Methods Classroom

Twenty-nine students, two of whom were male, took this elementary mathematics methods course. The course called for the student-teachers to have field experience in which they applied what they learned from the course to their classroom teaching practices.

The grade levels varied from kindergarten to fifth-grade according to each student-teacher's interest and the cooperating schools' situations. Since five students in the methods course (including Janie) had been teaching without certification, they worked in their regular classrooms, instead of in a cooperating school. Two student-teachers were placed in one classroom. Jill volunteered to work with Janie. The instructor suggested that they first work with a small group of students in the assigned elementary school classrooms until they felt comfortable in teaching a whole class. The students' field experience played an important role in the classroom discourse. The field experience was intended to give the student-teachers an opportunity to reflect on how elementary school students learn mathematics. The instructor often asked them to share their learning from the field experience.

The general objective of this methods course was to help the student-teachers be "reflective practitioners" who know well the materials they present, critique what they and others present, and listen actively to their students. The instructor did not attempt to transmit desirable teaching models. The objective was to help the student-teachers reflect on their own mathematical thinking and their students' thinking.

The instructor emphasized that the student-teachers themselves should think mathematically to help their students do the same. The instructor described mathematics as pattern, "patterns make up the structures of mathematics". He suggested that teachers recognize the structure of mathematics as well as that of students' understanding. The general atmosphere of the class was very active and permissive in that students asked questions without hesitation with topics often emerging from the interaction between the instructor and the students.

3. 2. Janie's Fifth-Grade Classroom

The elementary school in which Janie worked as a non-certified teacher is located in a suburban area in Louisiana. The majority of the students in the school are from lower-class African-American families. Janie's fifth class was comprised of 6 girls and 11 boys. Students sometimes came to school befo re school began. They had to wait outside of the classroom while Janie prepared lessons for that day. The class began with Janie getting their attention by saying "sit down, let's start." The first lesson was "daily oral language" which included language skills (*e.g.* correcting tense) and mathematical skills (*e.g.* adding a decimal to a whole number). Janie put some problems on an overhead projector and students solved the problems individually in their notebooks. Janie then checked the answers. Janie changed neither the style nor the content of the morning drill practice during my observation periods.

The classroom atmosphere was generally noisy. Janie also talked loudly. Students went around to sharpen pencils and to go to the bathroom. Voices in the air, a student who collected rolls, and visitors including other teachers often interrupted the class. Normally the students sat individually facing towards the board in the front. Janie sometimes organized the classroom into small groups in which four to five students work together. However, the frequency of using small group format decreased as the semester went.

Janie struggled with maintaining her students' attention. Whenver some students were inattentive in her instruction, Janie rebuked them. Janie very often emphasized classroom rules, for example, "I made all the rules. You do not speak until your name is called. Do not do it. I don't like noises" (Feb. 20). Also such rules as "Be Good and No Extra Responses" appeared on the board (Mar. 20). As well, Janie motivated her students by giving basketball game tickets to two students who followed the rules very well (Mar. 6). Students who repeatedly violated the rules had to sit in the back of the classroom by themselves.

3. 3. Janie's Teaching of Mathematics

Janie sometimes used small group activities. For instance, different groups were assigned to classify triangles, quadrilaterals, or pentagons. After each group's presentation, Janie emphasized the names and properties of the classified figures. Other small group activities included ordering a set of fraction cards. Instead of giving out fraction cards to small groups, one day she put each card on the back of some students and asked them to line up showing the numbers from the biggest to the smallest, or vice versa. The remaining students could direct the students on the stage. Janie often reinforced students' memorization of algorithms. For example, for the problem "2+300+0.006=", she asked students to put three dots first in re-writing the problem to the vertical format, to think about where decimals are in each number, and to fill out zeros in blank places.

The recurrent pattern of her teaching was to present a math problem using an overhead projector, to ask students to solve the problem, and to check the right answer. Janie usually picked out math problems from textbooks or instructional materials. The following was a typical classroom episode:

<Episode 1, March 13: *Numbers always make sense*>

Janie puts a new worksheet on an overhead projector. The problem on the worksheet is as follows:

> Which set of fractions is ordered from smallest to largest?
>
> a. $\frac{5}{8}, \frac{3}{8}, \frac{2}{8}, \frac{1}{8}$ b. $\frac{2}{4}, \frac{3}{4}, \frac{5}{4}, \frac{1}{4}$ c. $\frac{1}{4}, \frac{2}{4}, \frac{3}{4}, \frac{4}{4}$ d. $\frac{1}{4}, \frac{2}{4}, \frac{5}{4}, \frac{3}{4}$

Janie: (looks at students) Excuse me (taps the edge of the table with a pointer). Did you hear me? (starts to read the problem but stops soon) Kathy, I am asking you to pay attention to me. I've been asking for good manners all morning. Let's look up here (indicates the problem with the pointer). Desmond, don't keep talking when someone is talking. It doesn't take too much time to do that. Let's look up here, it's talking about number sense, from smallest to largest. On your LEAP [Louisiana Educational Assessment Program] exam, let me guarantee what you are gonna forget to do. You need to think about something from largest to smallest, or smallest to largest. If you don't know what they want you to do, just see the top number. Mike, what's the answer?

Mike: c.

Janie: That's right. Look at this (indicates the top numbers in the item c) 1, 2, 3, 4. (hides the bottom number, 4, with the stick) I'm sorry but this is all LEAP stuff. Let's look at this problem. (She puts up another worksheet.) Estimation is a part of number sense. Amy, move up the chair, please. I want a good audience. I don't want you to have conversation there. Karen, don't go without my permission. ... Enough, be quiet! [high tone] ⋯ Say this to me very lovely and in a whispered voice. Numbers make sense.

Students: (say together with rhythm) Numbers make sense.

Janie: *Numbers always make sense.*

Students: Numbers always make sense. (Some of them laugh.)

Janie: The more you see their patterns, the more they make sense. Numbers are nothing but pattern. They are always the same. Numbers never fail you. (Students repeat what Janie says phrase by phrase) That's enough.

Janie frequently mentioned "number sense", writing down "*# sense*" on the board. A general strategy to teach number sense for Janie was to present wrong computations and to ask whether such computations *make sense*. For instance, she wrote down "$2 + 2 = 2000$" in a vertical form and asked whether the computation was right, only to emphasize that 2000 is an enormous number compared with 2. Other wrong computations included "$\frac{1}{2}+\frac{1}{2}=5$" and "$222 \div \square = 987$", which students easily could correct. As in the above episode, Janie emphasized that numbers always make sense by repeating the sentence and asking her students to follow it.

Number sense is one of the main topics in the mathematics methods course. The instructor emphasized the importance of developing number sense. Instead of attempting to define or characterize number sense, the instructor provided some activities using a number line or number table in which students need to recognize relative magnitude of numbers, understand multiple patterns in number system, explore relationships among basic operations, and develop thinking skills with quantities represented by numbers. The above episode clearly reveals how Janie applied messages from the methods course to her teaching. According to Jill, "Janie talks about number sense, but she asks them [students] to memorize, I think, too much. It's not what he [the instructor of the methods course] says".

The following episode is a special case which clearly reveals Janie's lack of mathematical understanding. By accident, the problem has two answers. Janie struggled to find the right answer only to ask me in the middle of her thinking. It seems that she recognized the two answers, but was not sure of them. When Raina provided valid justification of her thinking, Janie did not probe Raina's understanding. She rather attempted to figure out the relative magnitude between $\frac{4}{8}$ and $\frac{4}{5}$ using her understanding of fraction as a part of whole. She tried to explain by drawing only to fail. Indeed, Janie always explained fractions as a part of a whole. Such an interpretation seemed to make her perplexed in this case. Though the methods course discussed fraction as a ratio as well as a part of whole, the episode reveals Janie's limited learning from the course.

<Episode 2, March 20: *That's why I am a little confused*>

Janie presents a fraction problem on the overhead projector.

> Which fraction is greater than $\frac{4}{8}$?
> a. $\frac{4}{5}$ b. $\frac{7}{8}$ c. $\frac{3}{8}$ d. $\frac{1}{8}$

Janie: What do you think? I want your opinion.

Students: b (Kentrell), a (Raina), b, b ⋯ (More students answered 'b'.)

Janie: Ya, numerically. (To Raina) Why is 'a' bothering you?

Raina: Because 8 is greater than 5.

Janie: Yes, 8 is greater than 5. Four out of eight pieces is four eights. Hey, hey, excuse me, think about number sense. Look up here. Hey, this is wrong, wrong. I want everyone to tell me. What does $\frac{4}{8}$ reduce to?

Students: One half.

Janie: It's one half. What will make, what's the next step to make one whole?

Students: Put it back, one whole.

Janie: That's bigger (pauses), $\frac{7}{8}$ is bigger (looks at the problem again and says to herself). Let's go through it. If we make, (tries to draw something on the board but stops) ... (Students make noises and she looks embarrassed.) I know, I know. ... (long pause). [to me] What is bigger? Everytime I figure out 4 pieces out of 8, 4 pieces out of 5. Which is an answer? [I said, 'a' and 'b'] I agree with you. That's why I am a little confused.

3. 4. Janie's Beliefs about Mathematics and its Teaching

(a) What is mathematics?

Janie said, "Math is a pattern. Math is done. Math is nothing but man's way of trying to figure out something." Specifically, she emphasized number sense in mathematics:

> "What the most important thing is good number sense, because numbers always make sense. Numbers have important patterns. The pattern is to put it back. ... Math, it's always there."

As mentioned before, the instructor of the methods class emphasized mathematics as pattern. However, there is a discrepancy in the understanding of mathematics as pattern. Whereas for the instructor patterns are powerful emergent and iterative, for Janie patterns are fixed and merely repeated. In relation to mathematics teaching, the instructor emphasized, "Let them [students] get a feel for patterns, not in a formal way. Just show them some patterns of mathematics and ask them to make more and more." Janie presented mathematical contents as fixed and predetermined. In her teaching, math is nothing but producing the right answer, but with little conceptual attention to why the answer works.

(b) What is good teaching of mathematics?

Janie said, "Good teaching is to make mathematics practical [so that] students see it in their world." She emphasized that visualization plays a fundamental role in the good teaching of mathematics in the following example presented during the interview:

> When trying to teach fractions, you need to think of the whole idea of what they are doing. They know, they have one candy bar, two candy bar. You should show how to symbolize fractions from the candy bars. People so often start putting only fractions, just saying denominator, numerator, least common denominator, et cetera. You got one candy bar, you got two, one and a half candy bar, they can see that. They can deal with fractions in their world. Or you can use pizza. You got one pizza, then split into eight pieces. You ate one out of eight pieces. Two, okay, in math, why don't I add up the bottom? Students can see it logically, how many pieces are there? It's eight pieces, not eight plus eight pieces they can see the process.

Indeed, Janie often used the candy bar model in her lessons for the computations such as "$1\frac{1}{2}+2=$?" She used concrete materials in order to help her students visualize mathematics. For instance, she used money to represent the relation between fraction and decimal. When teaching "$\frac{1}{4}=0.25$", she explained, "If you divide one dollar by four, how much money do you have? Yes, it's 25 cents. As you see, a fraction is married to a specific decimal". She also demonstrated the relations among measuring units such as cups, pints, quarts, and gallons with the support of various containers in different sizes.

Janie's emphasis on a visual basis seems to be compatible with the message from the methods course. The instructor frequently used several materials to illustrate mathematics as pattern, including a number line, 100's chart (number table), unifix cubes, pattern blocks, calculators, and computers for fractal programs. Moreover, the instructor provided theoretical background for visually-supported elementary mathematics, when he read from his paper in the class, "As we know from Piaget, the young child has a hard time thinking of one object as having two qualities *i.e.*, of a pencil being both long and thin. Either okay, both are hard. I like to approach place value on a visual basis first."

(c) Who is a good mathematics teacher?

First of all, Janie said that the role of a teacher is to cover all mathematical contents. Specifically, Janie tried to cover mathematical vocabulary for fifth-grade students. She frequently asked whether her students understand mathematical terms such as decimal, fraction, negative, digit, numerator, and denominator. For Janie, a teacher has a main responsibility to tell and show mathematics, and students learn best by attending to the teacher's explanations and demonstrations. She explained, "Just say again and again, just talk to them, just express to them. So all of that can be familiar to them. They can talk about mathematics. Eventually, they can manage it". Consistent with her beliefs about good teaching, Janie talked, explained, and showed much more than she listened to students. Her students' participation was limited to responding to her questions with simple answers. This was dramatically different from what the expectations of the methods course. The instructor explicitly emphasized in the first class, "We don't have any textbook. Our dialogue, our interactions will be a textbook. Not only did he ask the student-teachers to actively participate in the classroom discourse, but he consistently reminded them to listen more and more to their students. However, Janie did not express the concern of listening to the students' ideas either in the interviews or in her teaching.

Teaching mathematics for understanding is a major theme of the methods course and a part of Janie's beliefs about good teaching. Despite the visible differences between her teaching and recommended teaching in the methods course, Janie said, "I've done what he [the instructor] says exactly." However, Jill disagreed, "In the class, she [Janie] talks like what he [the instructor] says.

It's wonderful and great, and then she walks outside. In her classroom, it shuts down, no more in her classroom. Well, she is like a hypocritical person." What is the nature of such differences? Why couldn't Janie incorporate the approaches given in the methods course? What are the factors which make it difficult for her to teach mathematics meaningfully? What does Janie's experience tell us about the process of learning to teach mathematics? The following two sections inquire into these questions in terms of Janie's own qualities and the environment in which she teaches.

3. 5. Personal Factors Influencing Janie's Teaching

(a) Conceptual understanding

Teacher's conceptual understanding of mathematics is one of the main factors influencing his or her teaching practices (Kennedy 1998; Manouchehri 1997). Implementation of what Janie might have learned from the methods course requires her to have considerable mathematical knowledge and an extensive repertoire of pedagogical tools. The methods course did not provide detailed knowledge of mathematical contents to be taught in fifth grade, because the course had to cover all elementary school grades. For example, the course did not deal with the decimal and its operation, which Janie had to teach. The methods class focused more on whole number and its relations than fraction. Before starting a lesson about fractions, Janie personally expressed lack of confidence in teaching fractions. As revealed in Episode 2, she had a hard time dealing with fractions. Janie might need ideas and knowledge, which could be implemented almost immediately and directly into her classroom situation.

Another issue is about number sense the instructor emphasized throughout the methods course. What Janie learned and implemented was that "numbers always make sense" (Episode 1). As Resnick (1987) noted, number sense is hard to define precisely though it is relatively easy to list some features.

The *Standards* (NCTM 1989; 2000) provides five components of number sense: developing meanings of numbers, understanding various relationships among numbers, recognizing relative magnitudes of numbers, exploring relative effect of operating on numbers, and developing referents for measures. Janie's understanding of number sense was very limited to the recognition of unreasonable computations. Sowder (1992) claims that the attempts at defining number sense are not very helpful for directly guiding instructional efforts. Regardless of how we define and characterize number sense, if developing number sense should be one of the main foci in elementary mathematics (NCTM 1989; 2000), then student-teachers need to have opportunities to understand number sense in its multiple aspects.

(b) Janie's dualism

The influence of teachers' beliefs about mathematics and its teaching on their teaching practice is well established in the mathematics education literature (*e.g.* Battista 1994; Peterson, Fennema, Carpenter & Loef 1989; Raymond 1997; Thompson 1992). Janie's professed view of mathematics as a pattern reveals unreflected adaption from the methods course. In the term paper she submitted in the methods course, Janie introduced her ideal method of teaching, "Janie's dualism":

> [My] method combines different teaching modalities to appeal to learner differences with strategies to foster the development of an internal locus of control coupled with flat out rote learning, presented in the most logical, entertaining, and connected way possible within the limitation that it is rote learning.

Whereas the instructor in the methods course emphasized meaningful learning in comparison to rote learning, Janie attempts to *innovate* her own teaching style, which involves seemingly opposed things such as rote and meaningful learning, and teaching mathematics for understanding and skills. Specifically, Janie provided a rationale for rote learning in the interview:

> If something doesn't mean anything when you're learning it, then why learn it, or how can you use something if it doesn't mean anything to you? Well, am, is, are, was, were, have, has, had, do, does, did, may, might, must, can, could, shall, should, will, would, these are the helping verbs. I memorized that in third grade, but what does it mean to me? Not much! But, in a way, 'aye, there's the rub'. I'm not opposed to the rote method either ··· It's [knowing mathematical vocabulary] gonna take a certain amount of rote learning.

In this respect, Janie did not disagree with drill and practice. In her opinion, if students keep doing practice, they can develop strong mathematical skills and intuition. Thus, teaching mathematics by telling, showing, and checking is not necessarily conflict with teaching for understanding. Janie's approach to her students' development of mathematical skills is supportable from not only her dualism but other contextual factors which she had to face with.

3. 6. Contextual Factors Influencing Janie's Teaching

(a) Louisiana educational assessment program

As time passed, Janie mentioned more and more about the Louisiana Educational Assessment Program [LEAP], which is designed to measure proficiency in four subject areas including mathematics (Louisiana Department of Education [LDE] 1988). Janie expressed her sense of pressure about covering everything required for the exam. She started the semester by focusing on subjects in the exam such as mathematics and language arts, delaying teaching other subjects. In particular, she emphasized students memorization of algorithms through "daily oral language". The following was representative of this point: "When you see this [300 + 0.09] on your LEAP exam, we said this more than a hundred times, where does the decimal go? Just behind the whole number." As well, she emphasized mathematical vocabulary, asking them to explain the meaning of terms. LDE (1988) says, "The items are developed under the readability restriction that no words used exceed a fifth-grade vocabulary level" (p. 3). However, Janie argued that her students sometimes could not solve the items because they did not understand mathematical terms such as digit for number. Janie accepted and agreed with the need to prepare students for the test. Given that the items in the LEAP require students to learn specific target skills emphasized in the curriculum, she attempted to use skills-oriented teaching to achieve the best results.

The instructor's comment in the methods course was that if students understand mathematics then they naturally do well in exams. The theory of understanding before performance may not be a promising approach for Jannie, who had the external pressure of standardized test and wanted to see immediate outcomes of her teaching in terms of test score. In the interview Janie emphasized, "The best result, that's my best hope in the exam." Since Janie was a supplementary teacher, she might have wanted to prove her teaching ability by good test scores.

(b) Classroom management

Janie expressed much frustration and anger about her students' behavior both in her classroom and in the interviews. Her basic views were that a teacher must maintain classroom atmosphere of order and courtesy and that students learn best by attending to the teacher's explanations and by responding to questions. However, her students' behavior was not compatible with this view. Janie struggled with students' behavior and her teaching was often interrupted. During the interview, Janie recalled her previous teaching experience wherein she didn't have trouble in managing the classroom. She explained,

> The civilized students [from her previous class] came to me at the fifth-grade level. I didn't need to manage them. I was really a great teacher. I didn't have problems. Now, I just have 17 students. But I feel like teaching kindergarten or first grade. I am too tired. I want to be a teacher. I don't want be a behavior manager. I am not accustomed to managing students, like psychiatric kids, mentally retarded. I am angry.

Jill provided a different view from her observation of Janie's classroom and working with small groups in her classroom:

> Children are okay. They have conflicts among themselves. But I don't feel conflicts there. I feel conflicts with, perhaps, Janie. It may come from the LEAP test, 'cause she so worries about it. I also feel, it's probably that type of personality, that doesn't want to lose control of her class. I know that she has to maintain control in a class like she's got, behavior problems. I don't want to blame her, because I've never been there. But, personally, I will do differently. In my theory, in that situation, I will listen more to what students say.

IV. DISCUSSION: IMPLICATIONS FOR TEACHER EDUCATION

The process of learning to teach mathematics is complex. Janie had to integrate various messages from the methods course with her own beliefs and apply them to her own classroom situation. Some of her views of mathematics teaching were compatible with what she was expected to learn. However, generally speaking, her learning to teach from the methods course was very limited to the superficial applications. Janie found it hard to teach mathematics for understanding.

The methods course was different from traditional ones wherein students are expected to copy exemplary teaching models. Instead, the methods course encouraged the students to reflect on their views and clinical experiences of teaching mathematics. It is a common view that classroom teaching experience integrated with methods courses provides pre-service teachers with rich contexts for learning to teach. However, Janie's experience implies that changes in the methods course and clinical teaching experience do not lead inevitably to improved practice. We need to examine closely why student teachers, in spite of innovative methods course, are unlikely to change typical math teaching practice.

First of all, Janie's learning to teach math reveals how crucial subject matter knowledge is. Prospective elementary teachers tend to assume that they can teach math from their learning experience as students. As Janie's case reveals, however, lack of conceptual understanding on the part of the teacher prevents her from interpreting and appraising students' ideas, as well as constructing worthwhile tasks and activities. Without fostering sophisticated conceptual knowledge changes in the methods course are unlikely to lead to mathematics teaching for understanding. Such changes at best may lead to changes in the social norms of classrooms, for instance, from individual seatwork to small group activities. But they are unlikely to lead to changes in the *socio-mathematical norms* (Yackel & Cobb 1996) reflecting how mathematical concepts are embedded in the classroom culture.

Second, teacher education programs need to deal with contextual factors, which student-teachers have to face in their actual classroom teaching. Like Janie, beginning teachers might be very concerned about tests. They might not be able to attend to students' mathematical learning until they can successfully manage students and organize classroom procedures. If pre-service teacher education programs do not adequately address the practical aspects of classroom teaching, student teachers are apt to be strongly affected by the conditions of the workplace and easily enculturated into traditionally established school math culture.

Finally, the issue of carefully supervising student teachers in schools needs urgent attention. To be fair, the instructor in this study tried to visit each assigned classroom in order to examine his students' teaching. He also consistently asked for reflection and discussion of classroom teaching experiences. However, these attempts are by no means automatically realized as meaningful for students. Despite the dramatic difference between what was expected from the methods course and what was actually implemented Janie regarded her own teaching practice as reflecting the messages from the course. We need to closely examine the influence of teacher education experiences on the student teachers' understanding and implementation of mathematics teaching. In other words, in order for pre-service teacher education programs to become a more effective intervention, we need to know more about what student teachers learn through their professional preparation and provide precise and consistent supervision so that they constructively reflect on their teaching practices.

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