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Using Critical Incident Reflections: A Self-study as a Mathematics Teacher Educator

Research Paper

Pre-publication copy. For published version, see Goodell, J. E. (2006). Using critical incident reflections: A self-study as a mathematics teacher educator. *Journal of Mathematics Teacher Education, 9*(3), 221-248.

ABSTRACT

In this paper, I report the results of a four-year study into how my students learn to become mathematics teachers during the combined 15-week methods and field placement course I teach. At the start of most weekly methods class meetings, groups of three or four students reported their critical incidents to each other, and then chose one incident to report to the whole class. Each student then submitted a written report of ten critical incidents for grading. At the end of each semester, I administered a questionnaire about the usefulness of each of the elements of the course. Using these two main data sources, along with my own personal reflections on the course, this paper answers the question "What are the critical incidents preservice teachers encounter during their field experience, and what do they learn about teaching for understanding through reflecting on those critical incidents?"

My analysis of the students' incident reports found that the issues raised focused on four main areas: teaching and classroom management; student factors such as pre-requisite knowledge, understanding, resistance and motivation; issues concerning relationships with colleagues, students and parents; and school organizational issues such as policies and access to resources. Their learning about teaching for understanding focused on three broad areas: the conditions necessary to teach for understanding; facilitators of teaching for understanding; and barriers to teaching for understanding. The paper concludes with a discussion of the lessons learned about fostering reflection in novice teachers, and suggestions for further research.

USING CRITICAL INCIDENT REFLECTIONS: A SELF-STUDY AS A MATHEMATICS TEACHER EDUCATOR

INTRODUCTION

From August 1999 through December 2002, I taught a mathematics methods-course and supervised a 15-week practicum for four groups of secondary-mathematics preservice teachers at an urban university in a large American city. During this time, one of the major goals I have had for my students is to develop the habits of mind that enable them to learn from their own teaching, which according to Ebby (2000), should be a goal of every methods course. As Sullivan (2002) noted in the editorial of a recent edition of the *Journal of Mathematics Teacher Education*, "Studying teaching in simulated or real situations offers considerable potential for stimulating thinking not only about the application of theory to practice but also for creating personal theories for the study of practice. (p. 291)" Thus, there were two foci for this course. The first was to develop preservice teachers' understanding of the art of 'teaching for understanding'. The second, was to develop their capacity to think reflectively about their teaching—so that they could learn from their mistakes, learn to understand their students' thinking, and develop ways of thinking that will enable them to continue to learn as they become fully fledged teachers.

BACKGROUND AND LITERATURE REVIEW

Two main bodies of research informed the design of my mathematics education course. The first concerns teaching for understanding, and the second, reflective thinking in teacher education. In

this section I first present a review of both, and then conclude with a discussion of the course design and research questions that arose from the literature review.

Constructivism and Teaching for Understanding

Constructivism as a theory of learning relevant to mathematics teaching gained favor in the 1980's, and has remained the topic of extensive discussion ever since (Herscovics, 1996). Put simply, constructivism is a theory of how people acquire knowledge. Knowing mathematics requires learners to engage with mathematical objects in a community of learners, and it thus becomes the role of the teacher to establish an environment conducive to such activity (Davis, Maher, & Noddings, 1990), often referred to as a constructivist learning environment.

Ernest (1996) defined four types of constructivism: *information processing theory, weak constructivism, radical constructivism,* and *social constructivism*. He likens each type of constructivism to a particular metaphor of the mind, and provides a critique of each type. However, he also pointed out that they all share the metaphor of understanding as the building of mental structures, and that this must occur as the product of previous acts of construction, and not as received knowledge. Understanding of mathematical concepts has long been a goal of mathematics education (Carpenter & Lehrer, 1999), however recent publications on the subject by Carpenter and Lehrer (1999), Fennema, Sowder and Carpenter (1999) and Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, et al. (1997) point to the need to re-conceptualize many aspects of mathematics teaching to achieve this goal for all students. For example, Confrey (1990, p. 109), wrote "…one must reject the assumption that one can simply pass on information to a set of learners and expect that understanding will result." This implies that teaching mathematics involves much more than merely presenting topics, or covering the curriculum. In a constructivist learning environment, teachers must strive to build up the student's knowledge,

based on new input assimilated with information already known (Davis, 1996). By contrast, evidence suggests that traditional mathematics instruction methods that focus on review and introduction, followed by development and seatwork, do not promote student autonomy or the development of higher cognitive skills (Confrey, 1990).

Carpenter and Lehrer (1999) proposed five forms of mental activity from which mathematical understanding develops. These are (a) constructing relationships, (b) extending and applying mathematical knowledge, (c) reflecting about experiences, (d) articulating what one knows, and (e) making mathematical knowledge one's own (Carpenter & Lehrer, 1999, p.20). Engaging students in these mental activities to enable them to build their own understanding must be a central part of every mathematics classroom. Therefore, when teaching for understanding, teachers should ensure that they establish classroom norms that enable students to engage in this kind of mental activity, provide rich mathematics tasks that facilitate this kind of thinking, incorporate equity concerns so that all children have the opportunity to learn, and use assessment to continually monitor students' development of understanding (Fennema et al., 1999).

This creates a problem for many mathematics teacher educators, because as noted by Janvier (1996, p. 458) "…most of our students are invited to become a kind of teacher they have never observed before and work in a kind of mathematics they never did before." So mathematics teacher educators who want their preservice teachers to learn about teaching for understanding have to consider the implications this theory has for the teaching of mathematics and somehow incorporate these ideas into methods courses. I also wanted my course to be not only about constructivism as a theory of learning, but also constructivist in nature itself to take account of Janvier's (1996) suggestion that there should be constructivist conditions of interventions for training teachers, in which "the students should imagine themselves in at teaching situation" (1996 p. 458). Fortunately, in this case, my students were actually in a teaching situation, and

were therefore able to reflect directly on that experience. But what kind of reflection would be best? I turned to the literature about reflection in teacher education, which I discuss next.

Reflective Practice in Teacher Education

Reflection and the development of reflective thinking is a goal of many teacher education programs (Hatton & Smith, 1995). Loughran (1996) defined reflection as "the purposeful, deliberate act of inquiry into one's thought and actions through which a perceived problem is examined in order that a thoughtful, reasoned response might be tested out" (p. 21). Loughran (1996) also suggested that Dewey's five phases of reflection—suggestions, problem, hypothesis, reasoning and testing—form the structure through which this inquiry can occur, although not necessarily in that order. He also stressed that modeling reflection within the context of pre-service teachers' own teaching and learning experiences is crucial, and that a variety of artifacts of reflection such as journals and discussions can be used to accomplish this goal. However, Pultorak (1993) suggested three reasons why novice teachers have difficulty in engaging in reflective thinking. The first is educators' (including pre-service teachers) lack of time and structured opportunities for reflection, and their inability to look objectively at school-based experiences and benefit from them. The second is school supervisors' inadequate insight and enthusiasm. The third is university faculty members' demanding workloads that may interfere with their attempts to ensure that teacher preparation programs foster opportunities for reflection.

A particular focus for reflection was suggested by Lerman (1994), who discussed the use of critical incidents as a way to foster reflection in teaching, and found that comments from mentors and colleagues are essential in helping to "stimulate the consciousness of reflection (Lerman, 1994, p. 63)". A critical incident can be thought of as an everyday event encountered by a teacher in his or her practice that makes the teacher question the decisions that were made, and provides

an entry to improving teaching (Hole & McEntee, 1999). Zeichner and Liston (1996) identified five traditions of reflective practice in teacher education during the 20th century: academic, social efficiency, developmentalist, social reconstructionist, and "generic". Critical incident reflections follow the academic tradition in which "reflection on subject matter and the representation and translation of that subject matter to promote students understanding" (Zeichner & Liston, 1996, p. 51) is foremost. Hole and McEntee (1999) outlined a format for using critical incidents as a focus for professional development, in which incidents are not only discussed, but also written about. Feedback from colleagues given during class discussions of the incidents can be used to refine the incident reports. Using this structure helps address Pultorak's concerns raised earlier about the lack of structure of reflective activities, and helps make the act of inquiry into one's thoughts and actions more concrete and accessible to preservice teachers, who find it difficult, if not impossible, just to be asked to "reflect on your teaching".

Thus, reflecting on critical incidents in both verbal and written forms can be viewed from multiple perspectives in a mathematics teacher education program. First, critical incident reflections require more than just restating what happened. A reconstruction of the event is a central part of the critical incident protocol, and this then forces the teachers to engage in the kind of thinking that promotes the construction of their own understanding of teaching and learning (Korthagen, 2001a). Second, reflecting on a critical incident provides a structured framework for developing reflective practice skills that will enable them to develop their own knowledge about the practical aspects of teaching (Loughran, 2002). Third, the reflective process enables them to see their current practices as problematic through writing and discussing alternative paths of action that could have been followed, which according to Cobb, Wood and Yackel (1990) is the only way to impact the teaching practices of teachers. Fourth, discussing the critical incident reflections develops the capacity of the preservice teachers to engage in reflection as a social

practice, which according to Zeichner (1996), should be more of a focus for teacher education, to help teachers overcome the tendency to see all problems in their classroom as their own, which contributes to teacher burnout. Finally, in order to enable my students to come to terms with the mismatch that can occur between the teaching style of their cooperating teacher in practicum and the reformist vision of mathematics teaching I espouse in this course, reflection is crucial (Goos, 1999). Students who have to work with teachers whose teaching styles are not reformed need to be able to take account of and come to terms with their situation through reflection.

Course and Research Design and Rationale

Reflection and teaching for understanding were the foundation of all components of the class work and assessment for the course. In one of the first class meetings, we discussed at length the Carpenter and Lehrer (1999) article. Students worked in groups to examine the five forms of mental activity that lead to the development of understanding, and then made their own definitions of how to recognize when students understand a concept. We also completed a problem-solving task that required them to engage in each type of thinking, and then discussed the features of the task that made this possible. These activities then set the stage for all the future discussions about teaching for understanding that followed throughout the semester.

In subsequent class meetings, each student selected a 'critical incident' that happened either to them or to their cooperating teacher to discuss with a small group. After each member of the small group presented their incident to their group, each group chose one incident to report to the whole class. Although class discussions regularly took much more time than I originally intended, I judged this worthwhile due to their rich nature. After the discussion, each student submitted a written report of the critical incident, which had to describe the incident, why it happened that way, how the writer might have handled the situation differently, and what the

implications for her or his practice might be in future. (See Appendix 1 for the format of the critical incident reports.) Other elements of the course were specifically aimed at emphasizing the kind of mental activity proposed by Carpenter and Lehrer (1999) discussed earlier and at assisting students in developing reflective thinking and writing skills. These included hands-on mathematics problem-solving tasks, additional reflective components about in-class activities through an on-line discussion board; the construction of a personal philosophy of teaching at the beginning of the semester; and the writing of a final paper that engaged them in reflecting back on all of the activities over the semester, and discussing any changes they had made in their personal philosophy of teaching during that period. Only the critical-incident reports are discussed in this paper.

Since I first taught this course in 1999, I have been keen to monitor how well I was achieving the rather lofty goals I had set for my students to achieve in one semester. I conceptualized this self-study of my teaching in response to that query. I was particularly interested in the whether or not the class activities and assessments I had chosen for my students to engage in were effective in developing their knowledge of, skills in and dispositions towards teaching for understanding. In order to determine this, my research question focused on what they were learning through the critical incident reports and discussions, and how their learning was related to teaching for understanding. Thus, the research question answered in this paper is: What are the critical incidents that preservice teachers encounter during their field experience, and what do they learn about teaching for understanding through reflecting on those critical incidents?

METHODS

Self- study of Teaching

Self-study as a methodology has received much greater attention in the teacher-education research literature relatively recently (Zeichner, 1999). However, there remains considerable debate and some confusion about what constitutes a self-study methodology (Dalmau, Hamilton, & Bodone, 2002). One way of conceptualizing self-study is that it "…is defined more by the focus of the study than the way in which it is carried out" (Schuck, 2002). Self-study research typically utilizes a wide variety of qualitative methodologies, and seeks to answer a range of questions about teacher education practices that inform those inside the teacher education community and the larger community of scholars and educators (Zeichner, 1999). The definition of self-study by Dinkelman is the one that most closely reflects the design of this study: "intentional, systematic inquiry by a practitioner into her own practice" (2003, p.8). A compelling argument for teacher educators to engage in self-study of their teaching was recently provided by Dinkelman when he wrote "…if teaching is what teacher educators do, and teaching must include reflection, then self-study, as a form of reflection, ought to be an essential part of the activity of teacher educators" (2003, p. 8).

I conceptualized this study in the naturalistic tradition, which seeks to capture a holistic overview of the system being studied, and in which the researcher works "from the inside" (Miles & Huberman, 1994). I was trying to understand how well the activities I provided for my students had enabled them to learn about teaching for understanding in mathematics. My self-study involved looking back at the course records and the work turned in by the students after the semester had ended, as well as collecting some specific data about the students' opinions of the course activities.

Some have argued that a critical friend is a necessary component of self-study (Hamilton, 2002), however I have not had the luxury of enjoying such a relationship in my teaching situation. I see the process of self-study as my critical friend, since engaging in the process of reflecting on my experiences in the classroom, and writing this paper, has made me look critically and refine the practices I engage my students in. By opening up my practice for self scrutiny and scrutiny by others, I seek to improve it, which is often a goal of self-study (Schuck, 2002).

Validity Issues

I was cognizant of the possibility that students might write their reports to tell me what I wanted to hear in order to get a good grade. I attempted to deal with this in multiple ways. First, while I always wanted the focus of the class to be on teaching for understanding, I did not place any restrictions on the subject of their writing. If they were writing to please me, they would have always written about a mathematics-teaching episode, which they did not. I was also able to identify in their written reports many of the incidents I had already heard discussed in class, which is another indication that the written reports reflected their concerns, not mine, as I did not grade the class discussions in any way. In addition, when reading the written reports of incidents I had heard discussed in class, I noticed that some of the suggestions given by their colleagues or me during the class discussions were included in the reports. Second, I did not assign grades based on what the report was about (teaching, discipline, student motivation etc)—the grading rubric gave equal weighting to the four parts of the incident report (what happened, the outcome, the implications, what would you change). Third, to monitor what the students really thought about the critical incident discussions and reflections, I administered an anonymous questionnaire at the end of each semester, in which I asked the students to rate the usefulness of all of the activities we did over the entire semester and how helpful each activity was in developing their

understanding of teaching for understanding. Open-ended questions on the same questionnaire also elicited feedback about the most useful and least useful aspects of the course. I did not have access to these questionnaires until after I had submitted the grades, so the students could feel comfortable being truthful in their responses.

Data Collection and Sources

Context of the Study and Student Characteristics

While all my students were undertaking courses leading towards secondary teaching certification, the characteristics of their backgrounds differed widely. Some were traditional students: directly out of high school, they were completing their undergraduate degrees in mathematics at the same time as taking the certification courses. Others were postgraduate students with degrees in areas such as art, accounting, law and engineering. The mathematics content requirements for secondary teaching certification are the same for both undergraduates and graduates; so those graduates whose undergraduate degrees are not in mathematics had to take a considerable number of mathematics content courses, thus ensuring that their mathematics content background is substantial. In the second-to-last semester of the regular program, students enroll in my course, which includes a field experience of 180 contact hours, known as 'practicum', and a 4-credit-hour mathematics teaching methods course (the class meets for 4 hours each week for the entire 15-week semester). In the semester following this course, preservice teachers typically would undertake a 15-week full-time field experience, known as 'student teaching', which involved much more teaching, and usually occurred in a different school to their practicum placement.

My methods course was the only mathematics methods course that they would take. We met once each week for four hours in the evening, and they attended their practicum school every

weekday morning for approximately two-and-a-half hours for the entire 15-week semester. Teaching requirements built up gradually, so that starting around the tenth week of the semester, each participant taught a two-week sequence of lessons to one of the two or three classes being observed. I conducted formal evaluative observations three times for each student over the course of the 15-week practicum. The number of students varied each year (See Table 1 below). [1]

Data sources

The data for this study were collected over a four-year period, and consist of the written critical incident reports and end-of-semester anonymous questionnaires of students who were all in my combined secondary-mathematics methods and practicum class. Table 1 below shows a summary for each year of the numbers of students, incident reports and questionnaires I used in this study.

Insert Table 1 here

Also included are my own (unrecorded) reflections[2] about the nature and focus of class discussions and the type of feedback I would routinely give my students on their written work.

Students had to submit ten written incident reports for assessment. The format for these reports was included in the course syllabus at the beginning of the semester, and is reproduced in Appendix A. In the first class meeting, I discussed the format, stressing that I especially wanted them to reflect on what they learned about teaching mathematics from the incident, and what they would change next time they encountered an incident such as that. All work was submitted electronically; then, at the end of the semester, once the student had agreed to participate in my research, all ten of their incident reports were put into one document and made ready for the analysis.

The questionnaire asked the students to rate the importance and future use all of the activities that had taken place in the methods course. A copy of the questionnaire is in

Appendix B.

Data Analysis

I used the qualitative analysis software NUD•IST to assist with the coding and analysis of the data from the critical incident written reports. As I read each critical incident, I assigned a specific category, or in many cases, multiple categories to it, focusing on the main topics of student teachers' reflections. Once I had coded the data from the first two years, I reviewed the categories and found that four main themes emerged: teaching and classroom management; student factors such as pre-requisite knowledge, understanding, resistance and motivation; issues concerning relationships with colleagues, students and parents; and school organizational issues such policies and access to resources. These groupings are similar to the categories Loughran (1996) found in his analysis of students' concerns about learning to teach: issues about the course, self, classroom teaching, and learning. Once I had this broad framework, I coded data from the third year. No new major categories emerged from this data.

To answer the second part of my research question, which concerned what my students learned about teaching for understanding from reflecting on their critical incidents, I conducted a second content analysis of the students' critical incident reports. For this, I focused on those incidents about understanding that had been coded as *discovery learning (category 1,8)*, *student understanding (category 2,4)*, *student prerequisite knowledge (category 2,6).* This analysis enabled me to determine the factors, both positive and negative, which impinged upon their ability or willingness to teach for understanding.

FINDINGS

What are the critical incident reports about?

In Table 2 below, I have listed the categories that emerged, along with the number of critical incidents coded in that category. The total number of students who had an incident coded for each broad category is the first entry in each section. Tallying the number of incidents in each broad category would give a misleading impression of the relative importance of each category because many incidents were coded in more than one category; so the total includes many intersecting incidents. The incidents reported most often were concerned with student understanding, classroom management, assessment, student behavior, relationships with students, and student motivation.

Insert Table 2 here

For each broad category, the figures in bold in the table represent the total number of students who wrote at least one incident about that topic. Therefore, all students reported incidents about categories 1 and 2, but only 47% reported incidents about category 3, while 58% reported incidents about category 4.

Given that the main purpose of this investigation was to help me answer the research question "what do my students learn about teaching for understanding through reflecting on critical incidents"? I will not discuss all of the categories or sub-categories listed in Table 2. Only those categories that addressed some aspect of teaching for understanding will be discussed in the following sections.

Learning about teaching for understanding through critical incident reports and discussions

In answering the second part of my research question "What do pre-service teachers learn about

teaching for understanding through reflecting on critical incidents?" I utilized several data sources including the critical incident reports that focused on *discovery learning* (category 1,8), *student understanding* (category 2,4) and *student prerequisite knowledge* (category 2,6), my own recollections about the nature of class discussions that would follow the verbal presentation of critical incidents, and data from the end-of-semester questionnaire. There were a total of 101 incident reports in the three categories I used for this secondary analysis, which included 22 that were included in two categories and one coded at all three.

From the data, I identified three broad issues associated with teaching for understanding. There were the conditions necessary to teach for understanding, things that facilitated students' understanding, and things that were barriers to developing their students' understanding.

Conditions necessary to teach for understanding

The first category of learning was about the conditions that must exist in order to teach for understanding. Recognizing that students must have the necessary pre-requisite knowledge is essential to the success of any lesson, and is a frequent problem for pre-service teachers. In the lesson plan that must be prepared before teaching every lesson, my students must outline the necessary student pre-requisite knowledge. However their understanding of the importance of this often does not develop until they personally experience a situation in which lack of pre-requisite knowledge makes progressing through a lesson very difficult. For example, in the following incident report, Monica learned that building understanding of a new concept depends upon students being able to focus on the concept, not the arithmetic calculations associated with it.

> "I began my unit on distance and angle measure in my Geometry class. We started off with finding the distance of coordinates on a number line and then moving on to finding the midpoint of segments. I [thought]

> that it was going to be straight forward. I quickly realized that the students were not comfortable with adding and subtracting negative numbers. There were a lot of students asking how to do the problems because they could not work with the negatives. I think that students were more frustrated with the calculations and lost sight of the concept of distance. Next time, I would start the lesson with a review of some basic problems using negative numbers so that the students would feel comfortable with the calculations. If I have the students on track with the calculations, then they will have more time and energy to spend on the new concepts of distance and midpoints." (Monica, critical incident report, 2000)

Students' lack of computational skills can often hamper progress, and pre-service teachers find it hard to accept that their students have not mastered basic arithmetic. When incidents such as this are presented in class, we have a lively discussion about appropriate calculator usage, and the balance that teachers must strike between mastering basic skills and learning new concepts.

A second important condition necessary to teach for understanding raised by students in their incident reports is that of sufficient time to engage students in activities that promote understanding. The current political climate in the USA, with the emphasis on accountability through standardized testing (Conway, Goodell, & Carl, 2002) will continue to put pressure on the already over-full curriculum, which has often been called "a mile wide and an inch deep" (Schmidt, McKnight, & Raizen, 1996). We spend considerable time discussing how it might be possible to reconcile the opposing forces of time pressure due to many curriculum and assessment mandates, and the need to take more time to ensure understanding. Keith's comments in his report highlight a typical sentiment often expressed.

> "The implication is I'd better make sure the students know 'what' to do, before they know 'why' they need to do it that way. There is no time for the students to understand, they need to move on to the next subject and the next chapter. For this to happen I have to assign fifty problems and go up on the board and show them how to do it." (Keith, critical incident report, 2000)

Unfortunately, I do not have definitive answers to these dilemmas, which is frustrating, as

every teacher educator would admit. It also reinforces for me how important it is to provide a forum for my students to discuss the issues and hear from their colleagues, which they all appreciate. The worst thing I could do would be to ignore such issues and focus only on how to teach mathematics.

Student motivation to learn is another condition necessary to teach for understanding. In this incident report, Maria expresses her frustration in trying to establish the classroom norms that enable students to engage in meaningful mathematics that leads to understanding.

> "I would like to focus on critical incidents involving teaching math, but this week, I've become exasperated at the fact that many students won't do any work. When the focus work is up at the beginning of class, some of the students will just sit there and stare at it. Others, whom I [am sure] know how to do the problem, will just write down some quick arithmetic, instead of setting up the problem carefully. They then make mistakes, and don't get credit for the problems. This to me is a definite indicator of lack of motivation." (Maria, critical incident report, 2002)

My written response to Maria was:

> "You are doing all the right things with these students, but it seems that you are fighting a general lack of motivation. If they are unwilling or unable to work in class, that makes it very difficult. Don't beat yourself up too much for their lack of motivation. You are right on track with your activities." (Instructor's feedback in electronic critical incident report, 2002)

Providing this written feedback was an important way of providing added support and guidance, as many incidents were not discussed in class due to time constraints, and the written format provided another avenue for dialogue with me that would otherwise not have existed.

Whenever the issue of lack of student motivation was brought up in class, I always steered the discussion towards critically examining why motivation is such a problem. My self-study has ensured that I reflect on the value of discussing critical incidents, and I have learned that guiding discussions to focus on ways in which to better engage students is more productive than dwelling

on the negative aspects of the culture of some urban classrooms. We discuss the importance of ensuring that lessons are set in an engaging context relevant to students' lives, and that the mathematics is challenging and takes account of students' background knowledge. The use of "focus work" at the beginning of the period that is often unrelated to the remainder of the lesson is one reason why students may be disinterested or unmotivated. For some of my students, this is their first 'urban' experience. Urban settings in the USA are often greatly affected by social conditions related to poverty, family breakdown and mobility. While there is great variability in the range of urban settings, the tone of some schools can be significantly challenging.

Facilitators of teaching for understanding

The second category of learning was about some of the factors that facilitate teaching for understanding. The first factor is the importance of helping students make connections between abstract and real-world contexts, and ensuring that my preservice teachers understand that this is a critical part of their teaching role. In one of her reports, Pamela discussed how she helped her students make those connections.

> "The students seem to be learning in a vacuum. They are not seeing a connection between the material in class and the real world. It was only after some discussion did they begin to see the connection. Two days later when I used a similar set induction, they responded with much less prompting. … This situation has caused me to rethink my presentation of the material. I can see the importance of making the real world connection throughout a chapter instead of waiting until the end or until the problem solving section." (Pamela, critical incident report, 2000)

Pamela learned that it takes time and repetition for most students to make connections, and that she had to be explicit about the connections because students' are not accustomed to doing that for themselves. Critical incident discussions regularly included this topic, and I often redirected the students back to the readings completed early in the semester to reinforce these

ideas (see for example Carpenter & Lehrer, 1999; Romberg & Kaput, 1999).

Another factor that emerged from the data that facilitates students' understanding is providing them with the opportunity to make mathematical conjectures and test them. In my methods class activities, I always include many inquiry activities that could be used in the secondary classrooms my students will be teaching in, however the power of "discovery" is often lost on them because they already know the concept the activity is focused on. It is only when they try this with their own students, that they become convinced that the research we discuss and activities we do in class really do have the potential to significantly impact their students' learning. Frances describes one such occasion early in her practicum in this report.

> "… The one area they had trouble with was the Commutative Property. I decided to have all six students go up to the board. Each student had to make up a problem to determine if the commutative property was true for addition. Proving the properties seemed to help the students understand the concepts. I had read about trying to get students to come up with rules of math and I found that in this case it really worked. When they discovered that subtraction was not commutative they all got a very interesting look on their face that I can't really describe. It was the kind of look you get on your face when you make an unexpected discovery." (Frances, critical incident report 2001)

Providing students with these kinds of opportunities is what I want my pre-service teachers to be doing as often as possible. However, creating those opportunities is not easily accomplished due to the many constraints pre-service teachers experience. One of my greatest challenges as a teacher educator is to find ways to convince my students that they should be doing this. Even those who appear to be convinced, through their comments in class and in their reports, are rarely able to incorporate many inquiry activities. As noted earlier, I am asking my students to teach in a way they have never learned, which is a big leap. I ensure that I include as many inquiry activities as possible throughout the methods course, but lack of time is my biggest barrier.

Barriers to teaching for understanding

The third area of learning from the critical incidents concerned some of the barriers that must be overcome in order to teach for understanding. One such barrier is the assumption by many pre-service teachers that students are automatically able to make connections between a physical model and the mathematical representation of a concept. In his report, Leon discusses the use of a model when learning to add and subtract integers.

> "…When the Algebra 1 classes did adding integers, they were taught to use a number line. This helped them understand the idea behind positive and negative numbers, but when they had a homework assignment, many were unable to perform problems that extended even one or two numbers past the ends of their number lines. I personally would not omit the number line idea if I were to teach the lesson, but in addition to understanding the concept, I would make sure the students are able to complete tasks as well." (Leon, critical incident report, 2002)

Leon's observations are somewhat naïve as might be expected from a pre-service teacher. However, when incidents such as this were presented during class discussions, it provided an opportunity to reflect on the importance of being explicit about such connections whenever a model is used to illustrate a concept. I make sure that we use different models for operations with integers such as the number line and colored chips in the methods class, and emphasize the importance of ensuring that their students are able to generalize beyond the model. But, as previously noted, it is usually only when the pre-service teachers encounter situations in which their students have not made connections does it become meaningful. I have learned that my pre-service teachers need to experience this for themselves in an actual teaching situation, and that reflection, either written or verbal, is key to their realization of the importance of ensuring their students make connections between models and more formal mathematics.

Another issue that thwarted attempts to teach for understanding was the resistance by many

students to the problem solving or inquiry approach some preservice teachers tried to implement. Fiona discusses this resistance in her report.

> "I asked them to continue working on the problems, but most of them looked at it, decided they didn't know how to do it, and gave up. At least half the class did not even make any attempts at it. I'm not sure if they just didn't want to do it, or it looked too hard so they weren't even going to try. … It's tough because most students aren't used to figuring things out on their own, but instead are used to having a teacher explain something as soon as they say 'I don't get it'" (Fiona, critical incident report, 2001)

Incidents such as this helped me focus discussion on the importance of resisting telling students what do as soon as they encounter problems, so that over time, they get accustomed to persisting with problems. However, we also discussed the importance of providing appropriate hints so that students do not become too frustrated, as well as the importance of working through problems before assigning them to students to ensure that the problem is at the right level of difficulty.

Another important area of learning for my pre-service teachers is that their students can often do a procedure but not understand why it works, or how to apply their knowledge in a slightly difference situation. Gary describes one such incident this in his report.

> "…It was very difficult to help many of the students and I realized that most of the time the students just learn the procedures. Many of them have no idea why they do the things they do, and instead they just do them. I would ask them why or explain to them why they were doing something and it just seemed to confuse them even more. All that mattered was whether or not they did the problem right. The thing was since they didn't know why they had a hard time with problems that weren't exactly the same. It was very difficult and I don't have any answers." (Gary, critical incident report, 2002)

After an incident such as this is presented in class, we often discussed how memorizing a procedure does not equal understanding, but until a pre-service teacher has an experience similar to Gary's, they often do not appreciate its significance. I steered class discussion of incidents of

this type back to the readings on developing understanding through active involvement in doing mathematics (Carpenter & Lehrer, 1999) and to reflecting on the activities we had done in class that developed understanding through model building and inquiry, for example using algebra tiles to develop understanding of multiplying binomials, factoring trinomials and completing the square. I have learned that preservice teachers need to be constantly reminded that understanding rarely develops through memorizing procedures, and that they need constant support and encouragement to try activities that develop understanding.

Summary

Overall, there were 101 out 347 (29%) incident reports coded for learning about teaching for understanding, with 22 of them coded in more than one category. Of the 36 students for whom I have reports, 35 of them had at least one report in this category. I concluded that based on what they have written, and the fact that they were not compelled to write about particular topics, valuable learning about teaching for understanding did occur for the majority of students. The range of issues students learned about is too great to cover in this paper. However, those presented represent almost all of the responsibilities of teachers teaching for understanding referred to in the literature review.

End-of-semester questionnaire

As noted previously, I administer a short survey at the end of the semester to gather data about the students' perceptions of the value of each of the class activities. The first part of the questionnaire asks the students to rate each activity we did throughout the semester on two scales. The first question was "How helpful was this activity in developing your understanding of teaching for understanding?" The scale used was 5-Very Helpful, 4-Somewhat Helpful, 3-

Neutral, 2-Somewhat Unhelpful, and 1-Very Unhelpful. The second question was "How often, compared to this semester, should this activity occur during future EDS classes?" The scale used was 3-More Often, 2-The Same, and 1-Less Often.

The data for this survey spans four years[3], and I have a total of 38 completed questionnaires. In Table 3 below, I summarize the responses on each of the rating scales.

Insert Table 3 here

The highest rated activity on the first scale was "discussing critical incidents in class", while the writing of the critical incident report was equal fourth with observing peers teaching in class. On the second scale, which concerned how often the critical incident reports or discussion should occur in future, critical incident discussions rated equal first with engaging in hands-on activities in class.

On the same questionnaire, I also asked open-ended questions. The first was "Which aspects of the course were most valuable?" There were 34 responses to this question, and 16 mentioned the critical incidents as the most valuable aspect. The second open-ended question asked "Which aspects of the course were least valuable?" and no student mentioned the critical incidents. Having this kind of consistent feedback from my students each year has reinforced my notion that reflecting on critical incidents is a very valuable part of their learning to teach.

IMPLICATIONS

Through my self-study, I have learned a great deal about how to foster reflection in my preservice teachers, and how to ensure that they are learning from their reflections, which I offer to other mathematics teacher educators who may wish to use critical incident reflections with their own students.

Linking practicum and methods courses

Much of my students' learning from the critical incidents was made possible because their methods course was linked to an extended practicum experience. I had (some) control over their placements, and I not only taught the methods course, I also supervised their field experience, wrote the syllabi and had responsibility for all assessment and grading. This control enabled me to fully integrate both experiences. Through this linkage, my students had the opportunity to put into practice the methods they were learning in class and concurrently to reflect on their experiences, so that they could create their own "personal theories for the study of practice" (Sullivan, 2002, p.291).

Discussing critical incidents in class

Using actual experiences as the source of classroom discussions enhances relevance and meaningfulness, and compels students to construct their own knowledge about teaching. As noted by Korthagen (2001a), "A teacher's professional learning will be more effective when the learner reflects in detail on his or her learning experiences". The collective mistakes of the preservice teachers were used as learning opportunities for everyone, and, through group discussions, participants' derived personally relevant alternatives and solutions. Many of them commented that they would not have thought of handling a particular situation in the way in which it was presented, particularly when the discussion was about how the cooperating teacher expertly dealt with specific issues.

However, I have also learned that merely providing the opportunities for my students to reflect does not ensure that they are learning anything, a point echoed by Korthagen (2001a). It is important to monitor the class discussions, and keep them focused on mathematics teaching as much as possible. It is the reconstruction of the event through sharing with peers that is the most

important part of the process, a view shared by Loughran (2002). It is critical that the presenter is able to recount what they have learned from their experience. I did not insist upon this when I first started using critical incidents, but recognized the importance of doing so partly through my engaging in critical reflection as part of this study. Since I have been doing this more consistently, the quality of their written reports has greatly improved.

The class discussions certainly address Zeichner's (1996) concerns that reflection should be a social practice, in which teachers support each other's growth. Students often commented that they really appreciated the support they got from their colleagues during class.

Learning from written reflection on critical incidents

Since most of my students are not accustomed to "writing in math class", the first few reports some submit are very brief and do not fulfill the criteria, particularly in answering the third question which is "Discuss what implications this incident and its outcome has for your future teaching career". I will no longer accept reports that are lacking in this way, and require that these deficiencies be remedied. Getting some students who are so unaccustomed to reflect in this way is still very difficult, and I have found one semester often does not overcome their reluctance to do so.

The structured protocol the students were required to use provided a scaffold for them to reflect on their classroom experiences, and addressed Pultorak's first concern raised in the literature review concerning the lack of structured opportunities for reflection. By making their written reflections part of the assessment for the course, I addressed the issue of students not having time—I valued it enough to assess, so they had to devote time to it.

The instructor's role

My role in the class discussions and written feedback was to help my students make connections between what we read and do in the methods class with the realities of teaching in challenging situations, and to reassure them that they are on the right track or provide suggestions as to how to improve their practice. Because I am familiar with all of their teaching situations through my observations of them in the field, and because I have 13 years of high-school mathematics teaching experience, I am able to empathize with their issues and dilemmas, and can often present a range of viable options. I am also able to recognize and admit that I do not have all of the answers. The very diverse and sometimes competing goals of education in the USA today present significant challenges to my students entering the teaching force, but being able to teach for understanding is still a major goal I have for them when they leave this class.

CONCLUSION

The outcomes of my study have significant implications for mathematics teacher education that should be addressed to enable the next generation of mathematics teachers to fulfill the roles prescribed for them by the NCTM standards and mathematics teacher educators. Teacher education programs that are serious about developing of teachers' abilities to become reflective practitioners must make a commitment to assigning full-time faculty to field experiences, and to linking those experiences to methods classes.

Most mathematics teacher educators would agree that one semester of mathematics education is not nearly enough to "cover" all current issues in mathematics education. My students often make the comment to me that this is the most useful class they have ever had, and that there should be more classes like it, which of course I heartily agree with. I tell them that they should see this course as the start of their mathematics teacher education, and that the

reflective practice skills they have begun to develop in this class should help them continue to improve their teaching throughout their careers. Once they leave the supportive environment of this methods and practicum class, they have to become their own "Inner Mentor" (Jaworski & Watson, 1994), often with little formal support from the school district or their colleagues.

Teacher education programs must include opportunities for their pre-service teachers to learn about teaching for understanding by reflecting on actual teaching episodes. However, as noted previously, reflecting on their practice is something most preservice and novice teachers find very difficult to do. As noted by Jaworski (1994), there is a critical interplay between the researcher and the teacher when studying teaching through reflecting on classroom episodes that helps the teacher account for and develop his or her practice. My role in this regard was to force my preservice teachers to analyze critically their incidents through the writing of a report about the incident. My own reflections about this process were essential in helping me to recognize that the reports had no value unless the analysis was complete. My focus on research about the use of critical incidents has made me take an objective stance towards the students' concerns and ensured that I (eventually) insisted that the incident reports were completed. Had I not been engaged in this study, I may never have made that realization. Using the critical incident as the focus for reflection, and requiring analysis of the incident, as opposed to merely restating what happened as I have done in this study, has made effective reflective practice possible for my students and also for me.

This study adds to the dearth of description in the literature about activities that can be used to promote reflection in groups of preservice teachers (Korthagen, 2001b). By making clear the process I used and the obstacles I faced in implementing these activities, other mathematics teacher educators might avoid such obstacles in their own practice.

In this paper, I have presented a summary of the variety of critical incidents that pre-service

teachers encounter in their field experience. I presented a selection of types of things my students learn from reflecting on their critical incidents. I provided evidence that the pre-service teachers find these reflections to be helpful, and that they learn something valuable about teaching for understanding from them. I also demonstrated that the use of the critical incident discussions can open up a dialogue between the teacher educator and the pre-service teacher that may not exist otherwise.

Further research is needed to determine if specific categories of incident are specific to certain preservice teachers, how the focus of the incidents changes throughout a teacher's career, and if other teacher educators would come up with similar categories.

The richness of the class discussions, and the sophistication of the proposed solutions or changes, has even further convinced me that the critical incident reflection report and discussion is a very effective way to facilitate preservice teachers learning about teaching mathematics for understanding. My own teaching has been enriched by the critical-incident discussions, and by the ongoing data collection and analysis of the incident reports and end-of-semester questionnaires. Through my self-study, I, too, am engaging in reflecting on my own teaching, and modeling for the students the benefits of that process.

Appendix A

Critical Incidents Reflections 15%

You will write about critical incidents that you encounter each week in your practicum classrooms. A critical incident is an event you observed or participated in which caused you to question something or think critically about your own practices as a mathematics teacher. Over the course of the semester, you will document ten incidents. The written format for each entry will be as follows:

What happened - describe the circumstances leading up to the incident, exactly what happened, and why you think it happened that way.

The outcome - describe what happened as a result of the incident, and if the outcome was satisfactory from your perspective.

The implications - discuss what implications this incident and its outcome has for your future teaching career.

What would you change - discuss how you would respond if a similar situation were to arise again.

Please submit (electronically) reports every four weeks, after they have been discussed in class. We will spend time each class meeting for small group discussion of critical incidents. Please number each reflection consecutively (numbers 1 – 10), including the date submitted, at the top of the page.

DUE DATES:OCTOBER 1 (#S 1–4), OCTOBER 29 (#S 5–8), NOVEMBER 12 (#S 9-10)

APPENDIX B

Learning to teach mathematics for understanding
EDS 315/515, Fall Semester 2002
Exit Survey

Please circle the responses that best Reflect your opinion:

A. How helpful was this activity in developing my understanding of teaching for understanding.

B. Compared to Fall 2002, how often should this activity occur in future EDS 315/515 classes.

	Column A.					Column B.		
	Very Helpful	Somewhat Helpful	Neutral	Somewhat Unhelpful	Very Unhelpful	*More Often*	*Same*	*Less Often*
1. Participating in WebCT discussions about each week's class	VH	SH	N	SU	VU	*MO*	*S*	*LO*
2. Writing reflections about readings and responding on WebCT.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
3. Writing a weekly critical incident report.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
4. Discussing critical incidents in class.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
5. Writing self-evaluation after each lesson in practicum.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
6. Discussing lessons with cooperating teacher before teaching.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
7. Discussing lessons with cooperating teacher after teaching.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
8. Discussing lessons with professor before teaching.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
9. Discussing lessons with professor after teaching.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
10. Teaching mini lessons in Tuesday night class.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
11. Observing peers teaching mini lessons in Tuesday night class.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
12. Engaging in hands-on activities in Tuesday night class.	VH	SH	N	SU	VU	*MO*	*S*	*LO*
13. Writing final paper about influence of practicum on professional growth.	VH	SH	N	SU	VU	*MO*	*S*	*LO*

14. Which aspects of the course were most valuable?

15. Which aspects of the course were least valuable?

16. How can the instructor improve the teaching of this course?

17. How can the instructor improve the assessment of this course?

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Table 1
Data sources

Year	Students in both methods and practicum class	Student in methods only	Number of students with incident reports	Number of incident reports	Questionn-aires
1999	11	0	0	0	5
2000	8	0	6	58	6
2001	17	8	13	120	15
2002	17	9	17	169	17
Totals	53	17	36	347	43

Table 2
Number of critical incident reports in each category

Category	# of students	% of students	# of incidents	% of incidents
(1) Teaching and Classroom Management	**36**	**100**		
(1 1) Relationships with students	24	67%	37	11%
(1 2) Real-world applications	13	36%	17	5%
(1 3) Classroom management	30	83%	66	19%
(1 4) Lesson planning	21	58%	36	10%
(1 5) Assessment	12	33%	21	6%
(1 5 1) Proficiency test	7	19%	9	3%
(1 5 2) District testing	2	6%	2	1%
(1 5 3) Strategies and policies	14	39%	26	7%
(1 5 4) Feedback and follow-up	7	19%	13	4%
Total assessment	26	72%	60	17%
(1 6) Cooperative Learning	6	17%	6	2%
(1 7) Changing teaching practices	13	36%	23	7%
(1 8) Discovery Learning	14	39%	23	7%
(1 9) Time management	5	14%	6	2%
(1 10) Value of reflecting on teaching	2	6%	2	1%
(1 11) Teacher expectations	6	17%	7	2%
(2)Student Factors	**36**	**100%**		
(2 1) Motivation	26	72%	39	11%
(2 2) Behavior	25	69%	47	14%
(2 3) Participation	10	28%	12	3%
(2 4) Understanding	34	94%	76	22%
(2 5) Resistance to problem solving	10	28%	12	3%
(2 6) Pre-requisite knowledge	15	42%	25	7%
(2 7) Confidence	4	11%	5	1%
(3) Relationships and Professionalism	**17**	**47%**		
(3 1) Relationships with colleagues	3	8%	3	1%

Category	# of students	% of students	# of incidents	% of incidents
(3 1 1) Relationship with mentor teacher	10	28%	11	3%
(3 2) Relationship with parents	5	14%	7	2%
(3 3) Professionalism	10	28%	22	6%
(4) School Policies and Procedures	**21**	**58%**		
(4 1) School Policies	17	47%	26	7%
(4 1 1) Tracking and inclusion policies	5	14%	6	2%
(4 1 2) Tardy policy	3	8%	4	1%
(4 2) Administrative support for discipline	5	14%	8	2%
(4 3) Access to resources	4	11%	4	1%
(4 4) Legal issues	5	14%	6	2%
Number of students and total incidents reported	36	100%	347	100%

Table 3

End-of-semester questionnaire mean response

A: How helpful was this activity in developing my understanding of teaching for understanding

B: How often should this activity occur in future EDS classes

Class activity	A	B
1. Participating in WebCT discussions about each week's class	4.3	2.0
2. Writing reflections about readings and responding on WebCT.	3.7	1.8
3. Writing a weekly critical incident report.	4.5	2.1
4. Discussing critical incidents in class.	4.8	2.3
5. Writing self-evaluation after each lesson in practicum.	4.2	2.1
6. Discussing lessons with cooperating teacher before teaching.	4.2	2.1
7. Discussing lessons with cooperating teacher after teaching.	4.4	2.1
8. Discussing lessons with professor before teaching.	3.9	2.2
9. Discussing lessons with professor after teaching.	4.6	2.3
10. Teaching mini lessons in Tuesday night class.	4.2	2.1
11. Observing peers teaching mini lessons in Tuesday night class.	4.5	2.2
12. Engaging in hands-on activities in Tuesday night class.	4.7	2.3
13. Writing final paper about influence of practicum on professional growth.	4.3	2.0

End notes

[1] As the number of students enrolled increased significantly in 2001, I was unable to directly supervise all of them in the field work. All students still had to complete all of the same requirements for the critical incident discussions and reports irrespective of who was supervising them in their practicum.

[2] Although I did not record my reflections in a journal, this is the fourth paper I have written about this work, starting in 2000 with a conference paper (Goodell, 2000a) and journal article (Goodell, 2000b) using only the 1999 data. In 2002, I added the 2000 and 2001 data to my analysis, and wrote a new paper with this data (Goodell, 2002). In 2003, I began the analysis of all four years of data contained in this paper. Throughout this process, my reflections have been captured and reworked in the analyses I did as I drafted and finalized the paper.

[3] I include data from 1999 in the questionnaire, however I did not collect these students' critical incident journals.