PROSPECTIVE TEACHERS' ANALYSIS OF CHILDREN'S ERRORS USING CLINICAL INTERVIEWS

Roberta Y. Schorr
Rutgers, The State University of New Jersey
schorr@rci.rutgers.edu

Cecilia C. Arias
Rutgers University
carias@rci.rutgers.edu

Lisa B. Warner
William Paterson University
lwarnerb@gmail.com

Prospective teachers (PTs), enrolled in a mathematics methods course, were asked to analyze children's mathematical thinking by viewing videotaped clinical interviews over the course of an entire semester. They were also asked to conduct two of their own interviews with children as the semester progressed. While the type of analysis varied, all of the PTs commented on the errors that the children made during the interviews, often providing explanations for them. We describe these explanations and how they evolved over time. We note in particular that the PTs were better able to provide a more in-depth analysis of the videotapes than they were of their own interviews.

Keywords: Teacher Education – Preservice

Introduction & Theoretical Framework

Exposing prospective teachers (PTs) to situations in which they can observe and/or interact with children can provide them with the opportunity to better understand and appreciate the ways in which children think about, interpret, internalize, and represent various mathematical concepts (Ginsburg, Cami, & Schlegel, 2008; Author, 2000). One way to accomplish this is through the use of clinical interviews. Clinical interviews, as used by Piaget (1952), involve a flexible style of questioning which allows the interviewer to observe children's problem-solving behaviors as they work on tasks, and then ask questions that are tailored to the child's observed behavior. Ginsburg (1997; see also Mast & Ginsburg, 2010) notes that teachers' understanding of children's mathematical thinking can be enhanced through the use of clinical interviews—whether by actually interviewing the child, or critically observing another doing so.

As PTs engage in the practice of analyzing mathematical thinking through the use of clinical interviews, they often encounter situations in which the children think about the mathematics differently than they do. They may also be confronted with cases in which the children make errors. Without understanding the underlying reasons for the errors, the PTs may feel that the best way to deal with the situation is to redouble efforts to re-teach the concept, as interpreted by the PT or teacher, and not as understood by the child. In such cases, the PT remains unaware that the child may have a reasonable and logical rational for his thinking (Author, 2000).

Understanding errors can help teachers, both prospective and in-service, understand how children think about mathematical ideas. Ball (1991) notes that it is important for all teachers to consider the information that can be obtained by attending to children's errors, including whether the errors stem from simple calculation inaccuracies or more nuanced ways of thinking about a particular concept. Moreover, errors can be used by teachers to provide opportunities to stimulate mathematical discussions that further learning for the child making the error, as well as many of the other children in the class (Ball, 1991; Borasi, 1994; NCTM, 2000).

If PTs can learn to view children's errors as opportunities to learn more about children's

Martinez, M. & Castro Superfine, A (Eds.). (2013). *Proceedings of the 35th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Chicago, IL: University of Illinois at Chicago.

thinking, they may enter their teaching experiences better prepared to interpret and respond to children's complex ways of thinking. Consequently, one main goal of this study was to better understand when and how the PTs, all of whom were enrolled in an elementary/middle grade level mathematics methods course, identified, interpreted, and responded to children's mathematical thinking in general, and errors in particular (in both videotaped clinical interviews and interviews that they conducted), and how these interpretations changed over time. This relates directly to the conference theme that emphasizes broadening perspectives on thinking and learning. In this report, we focus on one PT in order to illuminate findings that are representative of the class as a whole.

Methods

Background

VITAL (Video Interactions for Teaching and Learning; Inoue, 2009, and Lee, Ginsburg, & Preston, 2009) was used in order to provide an online opportunity for the PTs to view and reflect upon archived clinical interview videos illustrating young children's mathematical thinking. It also allows for PTs to support their conjectures concerning children's mathematical thinking with video and text-based evidence.

Subjects

The subjects for the study were enrolled in the mathematics methods course for a full semester (September through December). Six PTs were chosen for more in-depth analysis based upon several factors: their attitudes towards mathematics and mathematics teaching as measured in a survey (White, Way, Perry & Southwell, 2006); their mathematical background (the number of mathematics courses taken prior to the class); and, their willingness to participate in the research study. Tania, the PT whose work is highlighted in this paper, was a female in her early 20s majoring in psychology. She had taken only the required mathematics courses (college-level algebra), and expressed anxiety about teaching math at any level (as per her survey results).

Data

The qualitative data for this study came primarily from the PTs' written work and audio-recorded classroom discussions. Their written work consisted of lesson plans, field observations, reflections on the archived clinical interview videotapes, and their reflections on their own clinical interviews with children. In all cases, the course instructors provided feedback to the PTs regarding their work.

Design

The VITAL reflections were assigned weekly, totaling 11 throughout the semester. In each, the PTs were asked to provide commentary on the mathematical behaviors observed in the videos, how the clinical interviews helped to provide information about children's thinking (covering topics including: number, numerical operations, geometric thinking, and patterns and algebraic thinking), and what questions or tasks they (the PTs) would have posed to a child had they been the interviewer. The PTs were also asked to support their claims with evidence from the videos and from assigned course readings. Of the 11 weekly VITAL assignments, there were seven in which the prospective teachers had the opportunity to identify and respond to children's errors. In addition to the weekly VITAL assignments, the PTs conducted their own clinical interviews at least twice (a third as extra credit). The first clinical interview assignment occurred approximately six weeks after the PTs began to work with the VITAL software. This was purposely done to allow the PTs to view others engaged in the practice of clinical interviewing, read about particular techniques used, and then prepare and conduct their own interviews. The

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second took place during the last three weeks of the semester.

Results

All six PTs commented on children's errors right from the outset. The level at which they reflected on the errors became increasingly sophisticated as the semester progressed, as will be highlighted below. Early on, their reflections consisted of simple descriptions of the child's error, noting when in the interview the child made an error. No further explanations or analysis were provided. As the semester progressed, the analysis increased to include possible explanations for the errors made by children including the following: confusion with learned algorithms; calculation mistakes; the child's understanding relative to a developmental level as described in the readings; procedural versus conceptual knowledge; confusion with the interview questions; difficulties with language and/or communication; desire to please the interviewer; and, incorrect or inappropriate use of manipulatives. Several of the PTs also posed follow-up questions or instructional strategies, which, if used, might provide evidence for the cause of the error, or help the child to self-correct.

In order to illuminate the above, we focus on one PT, Tania. We share some excerpts from her VITAL assignments to illustrate some of the ways in which she attempted to analyze children's errors.

In the excerpt that follows, Tania reflected on a third grade child, Henry, working on finding the solution to the problems of 8 + 7 and 13 – 7.

> Henry adds these two numbers perfectly in his head and even has his own unique strategy for finding the answer. Henry describes his strategy for adding the two numbers quite well. He says, "because 8 plus 8 equals 16 and 7 plus 7 equals 14 and that if he were to add 1 more to one of the 7's he would get 15". If he were to "add one less" to one of the 8's from the 8+8=16, he would get 15. Henry is less successful when he has to subtract 13 and 7. I don't understand how Henry was unable to do this because he described his technique for adding two numbers really well, and when it came to subtracting, Henry said that 13-7 was 5. Even when Henry explains his strategy he does not really apply it when he has to subtract. He does begin saying that "14-7 gives you 7 and because you have one less than I think there should be two less". And when he says I think there should be 2 less you can see that to him it does not even make sense because he makes a face like he's unsure.

Of the six case studies, Tania was the only one who made reference to a child's facial expression as an indicator of a child's discomfort with a response. Her explanation of Henry's thinking, while not extensive, did provide evidence of her attempt to understand his thinking. In the excerpt below, we note that Tania quoted the course textbook as part of her analysis:

> This made me think of chapter 9 of Van De Walle's book [the course text] … "Though the concept of less is logically equivalent to the concept of more, the word less proves to be more difficult for children than more". However, I also felt that perhaps Henry just made a mistake of trying to recall subtraction problems he was already taught to just memorize in school.

Note that Tania thought that Henry might just be recalling memorized facts. She also pointed out that Henry decided to do this "*by himself in Kindergarten*", a comment that surprised her.

In the fifth VITAL assignment, Tania's reflection provided a description of a first grade child's reasoning when writing down numbers that involved two or three digits.

> Tarik does very well writing a couple of numbers down… For instance, she writes down twelve and fourteen correctly as 12 and 14. However, when Tarik is asked to write twenty-one down she writes 201. I believe Tarik is just listening to the standard number word of

> twenty-one and writing exactly what she hears. Tarik hears twenty so she writes 20. Tarik knows the words but has not thought of them in terms of tens and ones. I do believe Tarik knows that the larger number like the 20 is on the left and the smaller number like the one in 21 is on the right, but has not exactly pinpointed where they go when we consider them in terms of their tens and ones place.

What Tania did next was to detail a plan that could have provided Tarik with an opportunity to develop a more accurate understanding of numbers and place value:

> I think Tarik should have been first introduced to the base ten language. So instead of saying twenty-one, the interveiwer [*sic*] could have said two tens and one ones. This might have helped her consider the tens and ones place when writing numbers. It would have also helped if Tarik used base ten blocks while developing an understanding of the oral names. Once Tarik became familiar with the base ten language, I might have given her a task where she would have to arrange some ones and tens I wrote down on the paper using the square-stick-dot method to create a number. I'd then allow her to say the number in the base ten language and the standard name and then have her write it down. This might be a good way for Tarik to connect all three components of the relational understanding of place value.

Tania detailed strategies that she believed could be used to develop relational understanding of place value, referring to the work of Richard Skemp (1978), who describes relational understanding as "*knowing both what to do and why*" (pg. 2), and which is referenced in the course text (Van de Walle, 2007). Tania also uses ideas from the course text for her teaching plan above which, in this case, describes the components of a relational understanding of place value as including base-ten concepts and the oral and written names for numbers.

Over time, Tania became increasingly interested in trying to understand the underlying nature of the errors that she saw. Consider the following example (VITAL assignment 6) in which Eddie, a first grade boy obtained an incorrect solution of two when subtracting 9 from 12. Eddie was asked to demonstrate his answer using chips. Despite the fact that Eddie ended up with three chips after removing 9 of the 12 chips, he still maintained that the answer was two, which was his paper-and-pencil solution.

> I believe Eddie tried to justify his answer of 2 by matching it to the answer on his paper despite that subtracting 9 from 12 left him with 3. I believe he tried to reason that since 12 and 9 were both large numbers subtracting one from the other would result in a small number because he tells the interveiwer [*sic*] that 12 and 9 are high numbers.

In this part of her reflection, Tania was intrigued by Eddie's insistence that the answer was two and not three, noting that Eddie said, "*12 and 9 are high numbers*". She also added another possible explanation for his answer:

> This clinical interveiw [*sic*] helped us to see that perhaps Eddie had falsely memorized what 12-9 was and even when he was asked to prove it he still believed it was 2. I think it also clarified that sometimes kids do conceive mathematics as a bunch of facts and rote memorization and despite giving Eddie an opportunity to prove it, he wanted the answer to just match the answer on his paper. I think from this interveiw [*sic*] we can see the importance of and having the "thinking curriculum".

Tania believed that Eddie may have just memorized the answer to 12 – 9. She tried to see the strengths in Eddie's thinking (he estimated very well what the answer was going to be). She also commented on the fact that his paper-and-pencil solution was the one that he used, regardless of the fact that he had just used his counters to come up with a different solution. This, Tania noted, was quite surprising.

> In the ninth VITAL assignment, Tania cited course readings to support her claim:
> The first shape Chidera [a pre-K child] is shown is a triangle and she correctly identifies it. When Chidera is presented with the next shape she is unsure of its name. The interveiwer [*sic*] then gives her some possible answers, one of which is a square. Chidera says that it is a square. When Chidera is given the third shape, she seems to depend on the orientation of the shape to name it. The third shape Chidera is given is a diamond, when one of its corners is on top and one is at the bottom, Chidera says its [*sic*] a dimaond [*sic*]. When the diamond is turned about 90 degrees, she says its [*sic*] a square. Like Dillion [a child in another video], Chidera seems to rely on visual prototypes for identifying shapes. I would also consider Chidera to be at level 0 [referring to the Van Hiele levels] because she relies on the appearance of the shape to define it and for Chidera the shape can change as it is rotated.

Tania's analysis was focused on when and how Chidera identified the shapes. She also related her observations to van Hiele's levels of geometric thought (as referenced in the course text), noting that Chidera was able to identify shapes based on appearance, but her ideas relating to the properties of the shapes were not fully developed. To Tania, this was evident when Chidera identified the square as such when it was placed on one of its sides, but called the same shape a diamond when it was rotated 90 degrees.

In the last VITAL assignment of the semester, Tania identified the difficulty one pre-Kindergarten child was having when asked to extend a color pattern with bears. She mentioned that she expected the child (Genesis) to be able to continue the pattern based on her behavior earlier on in the interview video:

> Genesis does not extend on the pattern correctly. She chooses orange and green bears to put into the pattern. When he [the interviewer] asks her what the green bear will match with, she say [*sic*] "nothing" and that it would be pretty if it was there. In the beginning of this video, I felt that Genesis was going to be able to extend on the pattern because when the interveiwer [*sic*] asked her what is this (referring to the pattern he created) she said its blue and yellow and blue and yellow. It appeared that she had noticed the sequence and would know what would come next. However, after reading the article, "Economopoulos" the author mentioned that to generalize and predict students must move from looking at a pattern as a sequence of what comes next to analyzing the structure of the pattern meaning to see that it is made up of repeating units… She [Genesis] doesn't understand the predictability and repetition that patterns imply because she would have been able to extend on the pattern correctly.

Tania used her understanding of one of the assigned course readings in her analysis of Genesis' response. Tania alluded to the situation in which a child may be able to identify a pattern but not be able to extend it.

We now share excerpts from Tania's own interviews with children to illustrate some ways in which she attempted to analyze children's errors in her own interviews. Tania's first interview involved a third grade boy named Billy. Tania's goal was to understand how Billy solved addition and subtraction problems. She began by posing several problems involving two digit numbers. She then shared a story problem in which Billy needed to find the total cost of buying a pencil for fifty-nine cents and a notebook for three dollars and twenty-five cents, as well as find the change someone would receive for the two items when paying with a five-dollar bill.

In her reflection, she noted that Billy tried to apply the traditional algorithms for addition and subtraction, but made some mistakes when subtracting. He also had difficulty in solving the subtraction part of the story problem above. She described, in the excerpt below, some of her observations, and noted in particular, how Billy's solution changed when she asked him to

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describe his process using actual money.

> When Billy subtracted and came up with the wrong answers I didn't think Billy was unable to subtract. I just thought it was because he did not know how and when to apply borrowing or trading using the traditional algorithm for subtraction because he had said he made a mistake and was supposed to change both 0's into 10's. I knew Billy was capable of subtracting because when I asked him if 5 minus 3 was actually 4, he demonstrated using the money that it was in fact 2. I don't feel Billy saw the connection between what he had just done and what he could have done for subtracting 3 dollars and eighty-four cents from 5 dollars.

As can be seen in the above excerpt, Tania was able to recognize the occurrence of errors in the application of the subtraction algorithm, but she did not provide an in-depth analysis or description of the possible root causes for the errors. She also did not pose follow-up questions that might have provided her with more information about Billy's thinking. After watching a replay of her interview, she noted that she should have asked Billy different questions. She wrote that she should have said, "*how can you prove to me that 5 dollars minus 3.84 would equal 4 dollars and 84 cents instead of saying show me this in a different way*". Tania felt that this would have allowed Billy more of an opportunity to explain his thinking.

In her second clinical interview (also with Billy), Tania decided to use a task that she had seen in one of the VITAL videos. The problem involved dividing 12 cookies amongst two children and then three children. In her analysis, Tania reported that Billy used a strategy of doubling or tripling numbers in order to calculate the answer (see below). She liked his solution strategy noting that it resulted in correct answers. She then decided to pose additional problems in order to find out how Billy would solve the problem when the numbers did not lend themselves easily to his strategy.

> …the next question I asked Billy was now to pretend that he only had 5 cookies and he wanted to share those 5 cookies evenly with 2 boys, how many would each person get. Since I saw that Billy was finding his solutions by doubling and tripling numbers that he picked, I thought I might give him another problem where he wouldn't be able to do this, but would still allow for the 2 boys to get an even amount of cookies. Billy thought awhile about this problem and then said it is impossible. I said, "impossible", and he said "yes, because nothing equals 5, like 1+1 = 2, 2+2 = 4, and 3+3 only equals 6." Then I said to Billy, so you can't distribute 5 cookies evenly among 2 people? He said no again. Therefore, I thought awhile about how I could rephrase it to Billy so that he might see at least two and a half cookies could go to each person. Then I said to Billy, "Well, what about if they are not even, how much could each person at least get, because if you have 5 cookies at least some of them can go to two people." I don't know if saying what about if they are not even were the right words to say, because Billy then said well one would get 2 and the other would get 3.

From the excerpt above, we see that Tania attempted to interpret what Billy said in terms of both how he thought about the problem, and the words that she had used in posing it to him. She noted, in particular, that the word 'even' was problematic. As she concluded her reflection of this interview, she compared some of Billy's thinking with what she had seen him do with the subtraction problem from the first interview she conducted. Tania noted a strategy she believed Billy used when thinking about the division for sharing cookies—the "*think-addition*" strategy that Van de Walle (2007) describes as "*What goes with the part I see to make the whole?*" (p. 148-149)—and suggested that he may have had less difficulty subtracting if he applied this same strategy to the subtraction problems from the first interview. At the end of her reflection, Tania

mentioned that she wished that she had asked Billy to draw a picture for the scenario of five cookies split between two children, explaining that maybe with a picture Billy might have realized that the extra cookie could be split in half.

We next share comments that Tania made about the utility of conducting interviews:

> I liked the VITAL assignments because unlike the field observations where you're watching an entire class in progress, they allow you to focus in on one student and his/her thinking… The VITAL assignments and readings were also helpful because they gave me ideas for what questions I wanted to ask the child I interviewed. The clinical interviews then allowed me to compare and contrast what I saw in the videos and readings. The interviews allowed me to put the readings into practice and that is something you cannot experience just from reading the book… I also had to listen attentively to Billy when I asked him to justify his solution so that I could elicit or challenge his thinking. In my second clinical interview, I noticed a pattern in Billy's thinking when he tried to find out how many cookies each person would get if they were distributed equally. Billy would begin by picking a number and doubling or tripling it. Therefore, I quickly came up with a follow up question I could ask Billy to challenge the way he originally thought about distributing the cookies. I would not have been able to do this if I had not listened carefully to Billy when he explained to me how he got his answers.

Discussion

As can be seen from the above accounts, Tania was able to identify the errors that occurred, and was better able to analyze them over time. She and several other PTs noted that it was easier to reflect on the errors that occurred in the VITAL videos than those that occurred during their own interviews. There are many possible reasons for this. Perhaps, as Tania and the other PTs noted, it is often easier to objectively analyze someone else's work than your own. Perhaps it is because the selected VITAL videos were both more professional nature, and chosen specifically to reveal certain aspects of children's thinking. Nonetheless, the PTs also noted that interviews performed by others appeared far easier to do than those that they actually did themselves. In particular, they noted that they were often confounded when a child made an error. They felt the pressure to make 'in the moment' decisions, which often led to comments and questions to the child that, in retrospect, did not address the error in a way that seemed productive. The PTs' post facto reflective analysis of their interviews indicated that at times, they did not have enough information to analyze children's errors because they had not asked the right questions or understood what really was happening during the interview. This highlights their realization of the skill needed, and importance of knowing how to respond to a child's thinking, especially when it is different than the way that was anticipated, or understood at the time it was being communicated. This is another of the many critical insights that the PTs gained as a result of their experiences.

The level and type of analysis presented in this report underscores the difficulty, yet importance, of having PTs reflect on clinical interviews. It further suggests the importance of using both videotaped interviews as well as personal interviews with children.

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