Novice College Mathematics Instructors' Knowledge for Teaching

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Abstract. In this qualitative study, we used analytic inductive analysis of interviews and teaching observations of 5 novice college mathematics instructors to explore instructors' learning about teaching. Our focus was how novice instructors analyzed and used knowledge of student thinking around grading. We interviewed instructors about their expectations, grading, and interactions with students for an in-class assessment. Instructors attended to student thinking in terms of perceptions of student readiness for the assessment, the nature of a "typical" student's thinking, and through reliance on self-reference to instructor personal experience. We identified a potential challenge to the construction of complex understanding of student thinking in that instructors believed that facility in communicating in standard mathematical forms was a natural outcome of mathematical understanding (not something taught).

The teaching practices of novice college mathematics instructors, such as graduate teaching assistants, shape learning for many students. Of the 15 million undergraduates in the U.S., 85% take mathematics service courses like college algebra and mathematics for future elementary teachers. These are the courses most often taught by novice instructors (Chen & Zimbler, 2002; Marincovich, Prostko, & Stout, 1998). Nationwide, the average pass-rate for these courses hovers around 60% while the other 40% of enrollees either withdraw or fail; moreover, half of mathematics and physical science majors switch to other majors, with 90% citing poor teaching as a reason (Seymour, Melton, Wiese, & Pedersen-Gallegos, 2005). How do we help novice college mathematics instructors learn to teach? To answer this question, we need to know more about the nature of the teaching practices of novice instructors.

Our perspective is that of advocate for rich learning opportunities both for undergraduates in mathematics classes and for the instructors who teach them. Like others examining the professional development of college mathematics teachers, our goal is finding ways to help

novice instructors empower themselves as teachers, to learn to teach from their own acts of teaching (Kung & Speer, 2007). Our epistemological stance is constructivist, we are interested in the nature and construction of knowledge for teaching by neophyte college instructors. To investigate the "chasms in knowing and learning practice" in collegiate mathematics, we structured this exploration of novice college mathematics instructor pedagogical content knowledge (Shulman, 1986, 1987; Ball & Bass, 2000, p.85) around interview protocols focused on instructor perceptions of student thinking as they planned, instructed, graded, and reflected.

Methods

We used criterion sampling (Creswell, 2007) based on participants' short experience as instructors in the courses they were teaching. They were *novices* in the sense that each was teaching a class for the first time and none had taught any course more than three times. All were at different stages of their academic careers (see Table 1).

Table 1. *Summary Information for the Five Instructor-Participants*

Pseudonym	*Graduate Status*	*New Course(s) Fall 2007*	*Previous Teaching Experience*
Ms. Alt	2nd year in master's program	College Algebra	Liberal Arts Mathematics
Mr. Bell	Lecturer - just finished master's	College Algebra, Statistics	Liberal Arts Mathematics College Algebra
Ms. Cielo	2nd year in PhD program	Activity-based College Algebra	Pre-Algebra Intermediate Algebra, Liberal Arts Mathematics
Mr. Douglas	4th year in PhD program	Business Calculus	Liberal Arts Mathematics College Algebra
Ms. Edgerton	5th year of PhD program	Math for Future Elementary Teachers	Liberal Arts Mathematics College algebra Calculus

We conducted three semi-structured interviews and one classroom observation with each of the five participants in the Fall 2007 semester. The first interview was prior to a class session we observed and ranged from 30 to about 55 minutes long. This *planning interview* was about what instructors were anticipating for the upcoming class meeting in terms of curriculum, student

activity, and instructor activity. It was followed by an observation of the participant *instructing*. A post-observation *reflecting interview* took place as soon as possible after the observed classroom sessions (within 1 day). In the planning-instructing-reflecting data, the topic of assessment arose as important to undergraduates and to instructors. To get a better understanding of assessment for instructors' knowledge construction about student thinking, we arranged for a *grading interview* of approximately 90 minutes with each instructor. These interviews happened on the same day that an instructor had administered some form of assessment in their class (quizzes of varying lengths for 4, exam for 1). Each instructor was asked to bring to the interview whatever they would normally use to go about grading the assessment (e.g., colored pen or pencil, book, calculator, rubric). As the instructors went through the process of grading, we asked them to think aloud about the process. Our semi-structured protocol included prompts about how and why student responses were graded in particular ways as well as questions about instructor interpretations of student thinking and performance, instructor intentions for communication, and instructor anticipations about student perceptions of the graded work.

Results

The preliminary results we report here focus on the use and generation of knowledge about student thinking by instructors during the grading interviews. Information from the planning-instructing-reflecting data provides background and supporting detail for those results. In talking about creating, using, and grading an assessment, every instructor referred to student "readiness" for the assessment and what student performance on the assessment would reveal to the instructor about how to move forward in class. That is, instructors were expecting to use knowledge about student thinking gained from the quiz as part of their anticipatory knowledge for instructional planning. Ms. Alt characterized her additional decision-making based on

awareness of her students' struggles as they were reviewing before the quiz by saying:

> *Ms. Alt*: Well, this quiz was different, too. I did not think that they were ready for it. And so I had them work on it alone and then I let them work together in pairs. I did not think that they were ready to do it on their own. There was a lot of confusion still.
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> *Interviewer*: So, that feeling of they cannot "do it on their own," it came after you passing out the quizzes, as they began to work?
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> *Ms. Alt*: No, we spent the first part of the class reviewing, and in their groups they seemed to be asking the same type of questions. I was not quite sure if they were ready …some of the comments that I got were: "You mean I can just use the quadratic equation here? Oh, and it will do the same thing?"… I think what I want them to take away from this quiz is to see how well they understand what's going on so I can gauge what I do on Monday. If we start the graphing or we come back to this [solving quadratics analytically].

Instructors regularly referred to "typical" and "usual" student thinking and relied on a virtual generic student (or students – referring to "the A student" or "C student" or "hard worker" and "slacker") in making decisions about planning assessment and instruction. However, in creating their quizzes, instructors reported relying on self-reflection on their own ways of thinking first, then reflection on the awareness they had of the challenges they categorized as "typical" for their students. Ms. Cielo and Ms. Edgerton agreed with Mr. Bell that they might not know whether a quiz question was a good way of getting at student thinking until after they had created a key. These three instructors and Mr. Douglas all reported that they generally created a key during or after giving the quiz to students. Ms. Alt said she worked the quiz questions before giving the quiz. Mr. Bell characterized his decisions about the importance of a quiz item, in terms of finding out about student thinking and in terms of grading [italics added]:

> *Mr. Bell:* I usually try to come up with [points based on] what I expect from my students, what I have seen from the class so far, and how the question is worded and *afterwards how I feel about the question*. Like *when I was writing the key, I had decided that the*

question was not going to tell me as much about what I wanted to know from the students …about how they think about these types of questions, as I wanted.

Interactions with student responses to assessments seemed more generative of new knowledge about student thinking for the more inexperienced instructors. The senior graduate students, particularly Mr. Douglas and Ms. Edgerton, focused on "getting it done, getting it graded" and giving feedback to students intended to "show them how to do it right." Exemplifying this is the comment by Mr. Douglas, echoing statements by Ms. Edgerton and Ms. Cielo, about the meanings of the marks he used as he graded (checks, circles, slashes, and question marks):

Mr. Douglas: If I strike it out, it's just there is nothing there. This doesn't make any sense. A circle, I use to say: "this calculation or number is incorrect." …To me a strike is more like, "you are way off base" whereas the circle is, "You're on the right track, you just did something silly like you divided incorrectly."…I sometimes use a question mark, too. It is like a slash: "What are you doing here?"

Interviewer: What do you think that a student is going to think those things mean?

Mr. Douglas: I would think that they would agree that the check mark is a good thing. Humm…maybe a slash through their work, they might think, "Okay, that was complete garbage." Or, I mean, I don't know. If they see a slash through their work, it might be kind of mean. …I don't know, it could be taken "He thinks that this work is not very good, he just crossed out everything." I could see how it could be taken in a mean way.

Interviewer: What do you think that the students would think about the question marks?

Mr. Douglas: Maybe less mean? I don't know what they are going to think. If I saw a question mark on my work, to me it would mean, it would be the same as I said before.

Noteworthy, towards the end of Mr. Douglas' last statement, is his reliance on self-reference, "If I saw …to me it would mean…" Similarly, on several occasions, Ms. Cielo reflected "when I took this class…" or "I wonder what the experiences of graduate teaching assistants are if they did not take this class." Ms. Alt and Mr. Bell attended to the personal circumstances of students as they reflected on ways to change their teaching in response to students' quiz work. That is,

their interaction with student thinking was generative in the sense that it seemed they were learning something about teaching through their interaction with the student work. We need more data to explore this seeming distinction between instructors.

Generally, instructors' conceptions of assessment scoring were connected to student engagement with homework. It is worth noting here that homework was regularly collected, read, and graded by Ms. Alt and Ms. Edgerton. Though Ms. Cielo, Mr. Douglas, and Mr. Bell regularly assigned homework, they "only graded for completeness." In responding to the question "What is a low student score telling you about the student's understanding?" instructor statements fell into two categories: "I don't know" (1 instructor) and "They need to do (more) homework" (4 instructors). When asked the question: "What are students getting from the quiz (score)?" instructors responded with one or more of the following three categories of answer:

"They get feedback from me on how well they understand the material."

"They know whether or not they are ready for the test."

"They see that they need to do better on homework"

Finally, in making decisions among potential scores, three instructors noted that they considered how the score might "make the student feel." Ms. Alt said that because she wanted scores "low enough to make 'em work harder, but not so low that they feel bad about themselves" she took care in giving 3 out of 5 on a quiz answer since "60% is like a D."

One final category of interaction with student thinking that we noted was a firm belief on the part of all five instructors that there was a difference between teaching mathematics and teaching students how to communicate in mathematics. That is, all five instructors asserted that students "should know how to write it if they understand it." As a group, instructors seemed to agree, "It's not my job to try to figure out whether the student is confused or bullshitting. In

either case, it's *wrong*." Each instructor spent some time on attempting to understand the non-standard mathematical forms students used on their quizzes; however after grading 4 to 6 student papers, all had moved into "coping mode, I've got to get through these, I don't have time to spend figuring out what they meant, I have to grade what they said." The curriculum for the courses of all five instructors included a state-mandated writing requirement, that students in each course learn to write about mathematics. About this, Ms. Cielo commented:

> We all [instructors in the seminar] feel writing is important to mathematics, but none of us want to grade those types of problems. It is time consuming and we are not sure if the confusions the students are experiencing are because of the mathematics register, English composition, or just mathematical concept misunderstandings.

Ms. Alt, Mr. Bell, and Ms. Cielo also all noted they felt they were learning how to shape their teaching, using interactions with students, through the teaching seminar they were attending.

Discussion

In their creating and grading of assessments, instructors used three types of knowledge about student thinking: student readiness, a "typical student," and self-reflection. We found possible evidence of growth of instructor knowledge of student thinking when instructors relied on connecting generalizations about the "typical student" to personalization that depended on the nature of the thinking of particular students. Most, though not all, of the knowledge of student thinking that appeared in our data was knowledge instructors used to make *a priori* decisions about what to do and how to do it (e.g., planning for class, writing a quiz or test), rather than knowledge that was generative of changes in teaching. That is, instructors were building anticipatory knowledge for planning and assessment, but connecting those anticipations to classroom teaching action was challenging for all five, particularly so for the most senior graduate students. Further exploration of Ms. Cielo, Mr. Douglas, and Ms. Edgerton's ways of

interacting with student thinking are needed; at this point we do not have sufficient data to go beyond noting that these instructors engaged in self-referential speech in talking about how students think approximately twice as often as did Ms. Alt and Mr. Bell. For Ms. Edgerton, Mr. Douglas, and Ms. Cielo their own experiences (and anticipated responses to potential experiences) were the most significant touchstone in their instructional decision-making for planning, for in-class action, and for assessing. We also identified a category of belief held by most of the instructors that seemed to do battle with their efforts to build their knowledge of student thinking when attempting to create and grade assessments, this was characterized by the statement, "If the student is really thinking, what they wrote will make sense [to me]".

Research suggests that an important aspect of improving college mathematics classroom teaching is identifying and helping instructors to develop their abilities to anticipate student interactions with mathematics and to enhance their capacities to act on these understandings about student thinking. The results of this exploratory study support the suggestions made elsewhere that planning, instructing, and reflecting are valuable activities in learning from one's own teaching (Little & Horn, 2007). In particular, we argue that a worthwhile site for professional development is in the ways we support novice college mathematics instructors in their planning, grading, and revision of assessments. Focusing the attention of instructors on constructing assessment items, predicting how students might work through or be challenged by them, and reflecting on the information available once students complete the assessment to inform next steps in teaching can create the necessary space for building knowledge about student thinking. In turn, constructing habits of mind that attend to knowledge of student thinking and the ways it can interact with instructional decision-making can support new college teachers in learning about teaching from their own teaching.

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