A Longitudinal Study of Mathematics Graduate Teaching Assistants' Beliefs about the Nature of Mathematics and their Pedagogical Approaches toward Teaching Mathematics

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Abstract: The purpose of this research study was to explore mathematics graduate teaching assistants' (GTA) beliefs about the nature of mathematics, their pedagogical approaches toward teaching mathematics and how these evolve over a span of a year. The GTAs participated in four open-ended interviews designed around the *planning, performing and assessing* framework of Speer and Kung (2009). Our preliminary analyses revealed hierarchical stages of GTA knowledge of their students as well as a separation between their ontological and pedagogical stances.

1. Introduction

It cannot be denied that communication of a subject is in part a reflection of the individual's view of that subject. Many have documented pre-service K-12 teachers' beliefs and have gone on to study how these beliefs influenced classroom practice. (For example: Cooney, T., Shealy, B. and Arvold, B., 1998; Day, R., 1996; Thompson, A., 1984; Thompson, A., 1992; Vacc, N. and Bright, G., 1999.) The harmony between the two is crucial. Austin (2002) discusses a number of issues related to professional development for future faculty members in general and further points out the importance of biography in understanding how beginning graduate students develop. An important aspect of doing so is understanding, how GTAs' beliefs about mathematics might be similar to or different from those of their students.

2. Methodology and framework

The five participants of this study were graduate students pursuing Ph.D.s in mathematics at a top research university in the Unites States. At the beginning of this study, the participants were in the first or second year of their program and all held degrees in mathematics. Except one participant all other had no prior experience in teaching college mathematics. The participants primarily led discussion sections and followed a standard curriculum while reserving the autonomy in how they structure the discussion sections or write the quizzes they give.

Data were collected in a series of clinical interviews, the first one being recorded during the GTA orientation week prior to the start of fall classes. The participants were interviewed three more times approximately at intervals of one semester. The open-ended interviews were designed following the framework of Kung and Speer (2009) of stages of planning, performing and assessing. Our premise was that initially GTA expectations of their students' view of mathematics were formed by their own experience and ideas about how mathematics is (ontological stance) and how a teacher of mathematics is (pedagogical stance). These expectations drove their practice (planning, performing, assessing). The practice generated assessments of their students (in-class/exam).

Research Questions: Our goal was to answer the following questions.

(i) Can the assessment results portraying in part how *students view mathematics*, reform the expectation which is formed by how the *GTAs view mathematics* (and thereby the practice that follows), if those are at a contradiction with one another?

(ii) What do the GTAs do faced with the reformed expectation? Do the GTAs separate their pedagogical stance from their ontological stance, in that they present a different view of mathematics to their students while keeping their own view for themselves?

3. Results and discussion

A preliminary analysis of the results of the first three interviews led us to gather further clarification in the final interview in the following categories:

1. GTA's ontological stance versus pedagogical stance
   a. GTAs' view of mathematics and the view they portray to their students.
      i. Theory-based (abstract) versus example-based (concrete)
      ii. Connected (deep) versus stand-alone (shallow)
   b. GTAs' preferred style of teaching (when they were taught) and the style they adopt as they teach, including
      i. GTAs' preferred definition (of the concept of limit) and the definition they offer to their students
      ii. GTA's preferred type of questions and the questions they ask of their students.
2. GTAs' views of struggles and rewards of teaching as well as remedies they suggested.

The preliminary analyses of this interview confirmed the following levels in GTAs' knowledge of their students

Stage A →Stage B1→ Stage B2→Stage C1→ Stage C2

Stage A Begin with egocentric model of students (e.g., students care only for their grades, not the knowledge)
Stage B1 Move to behaviorist observations (e.g., students react to task *x* by exhibiting behavior *y*)
Stage B2 Move to refined behaviorist observations (e.g., students can't think abstractly, for example in the case of negative T/F statements)
Stage C1 Move to cognitive explanations (e.g., students have difficulty coming up with counterexamples to justify a F response for a negative T/F statement)
Stage C2 Move to cognitive theories (e.g., students have difficulty with negative T/F statements because of no training interpreting logical statements)

We classify the stages B1 and B2 as behaviorist, and the latter two as constructivist.

Stages B1, B2: Teacher centered-knowledge of how students react to tasks (behaviorist)
Stages C1, C2: Student-centered- knowledge used to create cognitive theories (constructivist)

Below we present a glimpse of the GTA thoughts and practices with the example of Clara.

Example of Clara

Clara, a GTA who has been teaching for four semesters, is a graduate student pursuing her doctorate in the field of logic. She likes math for its abstract and rigorous nature, “Like if you prove something, you know it’s true and there is no discussion about it”, prefers theory and proofs to examples and applications for herself but not abashed about offering the students quite the opposite, because she knows “they don’t care about it” (the theories and the proofs) and that she doesn’t want to “make them feel confused about it”. She holds a rich and connected view of mathematics for herself admitting that challenging questions enriched her own understanding as a student, whereas provides her students with a user’s manual approach to calculus and straightforward questions so that “they don’t feel the pressure” to understand. She calls her approach as “adapting to her students” based on her knowledge that “they are not like me”.

At first we see her claiming how she is not bothered by this dichotomy of her as a student and her as a teacher, as she offers dismissive sentences such as “They pay me, so I do it” or the excuse that it is “harder to bring these features in Calculus”. However, as we go further the inner conflict becomes apparent by her disappointment that her students are not like her, that those “really amazing cool results” she learned in linear algebra are not the same for her students, when she finds that “most of the students probably don’t see or don’t care about this at all”. Or her admittance that if all her students exhibited the curiosity or cared about the material, she would “definitely” change her questioning patterns to include more challenging questions, “questions they can think about”. It gets further reconfirmed by the end when she chooses her one wish if she could change anything to make it more exciting for her as a teacher as having students who “want to be in the course”, who “want to understand”; perhaps not to the extent of her as a student, perhaps not to the level of a guaranteed understanding of mathematics, but as a step merely necessary in that direction.

Clara clearly demonstrates different ontological and pedagogical stances. But what stage is she at when it comes to her knowledge of her students?

4. Conclusion

The preliminary results of this study indicated a divide between the ontological and pedagogical stances of the GTAs resulting in a cognitive dissonance. In addition, we found that GTA knowledge of their students can be classified into two main categories; that of behaviorist-teacher-centered knowledge of how student react to tasks, and constructivist- student centered knowledge used to build cognitive theories. Further analysis will be undertaken to explore how the constructivist approach gets embedded into planning, performing and assessing to offer *cognitively guided instruction* (Fennema et al., 1996) as well as how the cognitive dissonance affects a GTA's pedagogical approach.

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