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The mathematical beliefs and behavior of high school students: Insights from a longitudinal study

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ABSTRACT

There is a documented need for more research on the mathematical beliefs of students below college. In particular, there is a need for more studies on how the mathematical beliefs of these students impact their mathematical behavior in challenging mathematical tasks. This study examines the beliefs on mathematical learning of five high school students and the students' mathematical behavior in a challenging probability task. The students were participants in an after-school, classroom-based, longitudinal study on students' development of mathematical ideas funded by the United States National Science Foundation. The results show that particular educational experiences can alter results from previous studies on the mathematical beliefs and behavior of students below college, some of which have been used to justify non-reform pedagogical approaches in mathematics classrooms. Implications for classroom practice and ideas for future research are discussed.

1. Introduction

In the past three decades there has been extensive research on students' epistemological beliefs. This research has contributed several insights into students' views on what knowledge is, what it means to know, how learning takes place, and what teaching should look like. The insights have been reported in several reviews of the field (see, e.g., Hofer & Pintrich, 1997, 2002; Op't Eynde, De Corte, & Verschaffel 2002; Pehkonen & Hannula, 2004; Thompson, 1992). Yet, more research is still needed in this area. Most research on students' beliefs has taken place at the college level. Few studies have taken place at the high school level, and even fewer in lower grades (Hofer & Pintrich, 1997, 2002). Also, although several studies have examined the impact of teachers' beliefs about learning and teaching on their teaching behavior in mathematics classrooms (e.g., Barkatsas & Malone, 2005; Beswick, 2004, 2005; Cross, 2009; Karaağaç & Threlfall, 2004; Ng & Lopez-Real, 2003; Stipek, Givvin, Salmon, & MacGyvers, 2002; Vartuli, 1999), there is a lack of research on the impact of students' beliefs on learning on their behavior in mathematical tasks.

The purpose of this article is to help address this gap mentioned above by reporting on a study that examined the beliefs on mathematical learning of five high school students and the impact of the beliefs on the students' mathematical behavior in a challenging probability task. The students were participants in an after-school, classroom-based, longitudinal research on students' development of mathematical ideas.[1] The results show that particular educational experiences can alter the

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results from previous studies on the mathematical beliefs and behavior of students below college (e.g., Beswick, 2004; Hofer & Pintrich, 1997; Kloosterman, 2002; Ng & Lopez-Real, 2003; Vartuli, 1999). Some of the results have been used by mathematics teachers to justify pedagogical approaches not consistent with the ideas of reform movements in mathematics education (see e.g., NCTM, 2000).

2. Research on beliefs and behavior of pre-college students

Few studies have examined the beliefs on mathematical learning of students below college and even fewer have looked into how such beliefs impact the students' mathematical behavior when working on mathematics tasks. As result, researchers have relied on results from research in closely related areas for insights on such issues. Hofer and Pintrich (1997) point out that there is a tendency to assign students below college naïve epistemological belief simply because research shows that this is the case among students starting college (Perry, 1970, 1981). A survey on the mathematical beliefs of high school students revealed that the students expected their teachers to explain everything they were supposed to do, to describe mathematics as a set of procedures, and "never mentioned deduction and proof" as an important component of a mathematical activity (Kloosterman, 2002). Such expectations are not consistent with sophisticated beliefs on learning or "doing" mathematics.

Research on how mathematics teachers' beliefs on students' abilities impact their behavior in mathematics classroom also shows that mathematics teachers often assign naïve views on mathematical learning to students below college. In particular, they use it as an argument to justify teaching approaches that are not consistent with the principles of reform movements in mathematics education even when they agree with the principles. Beswick (2004) reported the case of a mathematics teacher who professed beliefs about learning and teaching that were consistent with the reform movements in mathematics education. Yet, the teacher taught according to such principles only his seventh-grade students, and not his tenth-grade students. The teacher's argument was that tenth graders were "a totally different kettle of fish" (p. 116) as "older students of average ability are not interested in mathematics and needed only "survival *numeracy skills*"' (p. 116; emphasis added). Therefore, in the tenth-grade classes, the teacher provided limited opportunities for whole-class discussions and student questions. Instead, the teacher showed or told students what to do, and claimed that it was not a major issue if several students did very little work, as long as they behaved properly. Similarly, Ng and Lopez-Real (2003) found that primary teachers were less likely than kindergarten teachers to teach according to their professed beliefs in the principles of the reform movement. The teachers cited pressure from parents and school administration to focus on grades and use of inappropriate textbooks. However, the teachers also argued that "especially in lower primary, they [children] need to *compute* more in order to *master* the mathematical concepts" (p. 218; emphasis added). The teacher emphasized skills and procedures rather than mathematical understanding in those grade levels. Ng and Lopez-Real (2003) agreed with Vartuli (1999) who concluded that "it appears that as children get older they are allowed [by teachers] less responsibility for their learning" (p. 213). In other words, the older the students, the less they were allowed to build their own knowledge, i.e., to have agency in learning.

A survey study on the beliefs of high school students by Schoenfeld (1989) provided an insight on the impact that students' beliefs on mathematical learning can have on their mathematical behavior in challenging mathematical tasks. The students claimed that mathematics was about "thinking." However, they also argued that if someone knew how to solve a mathematical problem, they would be able to do so quickly, that is, in no more than 12 min on average. This suggests an inconsistency between students' views on learning mathematics and the students' potential mathematical behavior in mathematical tasks, whereby students would give up trying to solve a challenging problem *too quickly*, despite claiming that mathematics is about thinking. Yet, as Schoenfeld (1989) notes, "What counts in problem-solving situations is students' behavior and not so much their professed beliefs, which often reflect no more than the students' appropriation of a "rhetoric"—rather than "substantive insights"—about mathematics and how it should be learned" (p. 349).

This study examined the view on mathematical learning of five high school students and their mathematical behavior in a challenging probability task. The purpose was to gather insights into how students' views might impact their mathematical behavior in challenging mathematical task and how particular mathematical experiences such as the longitudinal study might influence the students' beliefs. Three research questions guided the study: (1) what are the students' belief about learning mathematics? (2) What evidence, if any, is there that the students' beliefs had an impact on the students' mathematical behavior in the probability task? and (3) What evidence, if any, is there that the particular experiences in the longitudinal study helped shape the students' beliefs on learning? The answers to these research questions may contradict the results from previous research. Additionally, the results suggest that particular educational experiences can alter these results on pre-college students' beliefs and behavior.

3. Theoertical framework

3.1. Defining "beliefs"

There is no consensus on a definition of beliefs (e.g., Furinghetti & Pehkonen, 2002; Hofer & Pintrich, 1997; Leder, Pehkonen, & Törner, 2002; McLeod & McLeod, 2002; Pehkonen & Hannula, 2004). The discrepancies are such that "it is sometimes not clear whether researchers are discussing the same intellectual territory" (Hofer & Pintrich, 1997, p. 111).