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Are beliefs believable? An investigation of college students' epistemological beliefs and behavior in mathematics

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ABSTRACT

College students' epistemological belief in their academic performance of mathematics has been documented and is receiving increased attention. However, to what extent and in what ways problem solvers' beliefs about the nature of mathematical knowledge and thinking impact their performances and behavior is not clear and deserves further investigation. The present study investigated how Taiwanese college students espousing unlike epistemological beliefs in mathematics performed differently within different contexts, and in what contexts these college students' epistemological beliefs were consistent with their performances and behavior. Results yielded from the survey of students' performances on standardized tests, semi-open problems, and their behaviors on pattern-finding tasks, suggest mixed consequences. It appears that beliefs played a more reliable role within the well-structured context but lost its credibility in non-standardized tasks.

1. Introduction

The role of college students' epistemological beliefs (i.e., beliefs about the nature of knowledge and knowing) in their academic performance of mathematics has been documented and is receiving increased attention. In general, studies of epistemological beliefs at the college level can be traced back to Perry's (1968) survey of undergraduates' intellectual development. He found that college freshmen typically espouse a belief that knowledge is simple, certain, and assorted in canonical form. Schoenfeld (1983) explored the influence of college students' epistemological beliefs about mathematics on their problem solving ability. Students' non-cognitive behavior led Schoenfeld to establish an evidence-based framework of mathematical problem solving in which belief systems play the most fundamental and subtle role (Schoenfeld, 1985). In terms of Schoenfeld, purely cognitive behavior is rare and individuals' perspectives regarding the nature of tasks may affect their intellectual performance within a particular context. Namely, one's mathematical worldview shapes the way one does mathematics (Schoenfeld, 1985, 1992). Schoenfeld's claim has been generally endorsed by several studies conducted during the 1990s and early 2000s (Carlson, 1999; Higgins, 1997; Kloosterman & Stage, 1991; Presmeg, 2002). However, to what extent and in what ways problem solvers' beliefs about the nature of mathematical knowledge and thinking impact their performances and behavior is not clear and deserves further investigation. The present study attempted to delve into the issue through investigating Taiwanese college students' epistemological beliefs about mathematics and analyzing multiple facets of their problem solving performances and behavior.

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2. Theoretical background

The early literature had indicated that, in the search for knowledge, we do not start from a neutral zero and the human mind "is a belief-seeking rather than a fact-seeking apparatus" (Jastrow, 1927, p. 284). Belief is seen as an individual's psychological state regarding the truth of particular propositions or personal premise for specific objects. It is the result of reflecting on actions that may or may not be knowledge-based and intellectually verified. Following two decades of studies on mathematical problem solving during the 1980s and 1990s, it has been generally assumed that individuals' mathematics-related beliefs may have a significant impact on their mathematical thinking and behavior. Nonetheless, owing to its complicated and contextualized nature, a widely accepted definition of belief is lacking and the discourse on how it works is diverse. The loose use of definition and varied interpretations may explain why the role of beliefs in mathematics education remains peripheral and hidden (Leder, Pehkonen, & Törner, 2002; MacLeod, 1992). Apparently, "research on this topic has not yet resulted in a comprehensive model of, or theory on, students' mathematics-related beliefs," and "the state of the art of the research field does not allow the development of a comprehensive theory at the moment" (Op't Eynde, De Corte, & Verschaffel, 2002, p. 15).

Rokeach (1968) defined belief as "any simple proposition, conscious or unconscious, inferred from what a person says or does" (p. 113), and distinguished its content into descriptive belief, evaluative belief, and prescriptive belief, which are different but interrelated components (Fig. 1(a)). For instance, "I believe students learn something useful in school," is descriptive and "I believe mathematics is useful," is evaluative. A mixture of the two beliefs may entail "I believe students should learn mathematics," which is prescriptive. Törner (2002) structured mathematical beliefs in a hierarchical form in which global beliefs (general beliefs of teaching and learning), domain-specific beliefs (beliefs about specific domains such as algebra or geometry), and subject-matter beliefs (beliefs of amount and organization of the subject) interact among each other via top-down or bottom-up influences (Fig. 1(b)). In terms of Rokeach and Törner, "I believe students should learn more algebra than geometry in school because algebra is more useful than geometry," is categorized as a domain-specific evaluative belief. Taking its multi-faceted natures into account, focusing on a certain particular belief rather than exploring the whole belief system may be more feasible and rewarding (Pajares, 1992).

Epistemological beliefs refer to beliefs about the nature of knowledge and knowing. During the past decade, the study of epistemological beliefs has increasingly received attention among educational psychologists. Relative findings suggest epistemological beliefs are linked to students' academic performance in a distinct context (Bendixen & Hartley, 2003; Kardash & Howell, 2000; Schommer-Aikins, Duell, & Hutter, 2005; Whitemire, 2004). While exploring the relationship between undergraduates' epistemological beliefs and information-seeking behavior in a digital environment, Whitemire (2004) found students at higher stages of epistemological development displayed better ability to evaluate information sources and to deal with conflicting situations. Bendixen and Hartley (2003) not only claimed that pre-service teachers' epistemological beliefs were significantly related to their achievement in a hypermedia learning course, but also suggested that epistemological beliefs were more linked to ill-defined problem solving. Furthermore, a quantitative survey conducted by Kardash and Howell (2000) indicated college students viewing the process of learning as clear-cut and unambiguous tended to believe that memorization plays a major role in learning and knowledge can be known with certainty.

Schoenfeld (1983) had performed the pioneering work in the specific domain of mathematics. Through investigating how two college freshmen approached geometrical construction tasks, he asserted that purely cognitive problem solving behavior was rare and individuals' belief systems of mathematics played a key role behind the scenes. His succeeding surveys (Schoenfeld, 1988, 1989) not only endorsed his previous claim, but also further suggested that students' mathematical behaviors seem to be driven by earlier experiences that shape their subsequent beliefs. Kloosterman and Stage (1991) also found low college mathematics achievers generally had a poor conception of the nature of mathematics, and their beliefs about mathematics were related to the final course grade. By employing VAMS (Views About Mathematics Survey), Carlson (1999) found mathematics graduate students held expert-like views, while pre-calculus students held common views. Furthermore, by observing the graduate students' problem solving behavior while completing complex mathematical tasks, she suggested that non-cognitive factors play a prominent role in a student's mathematical success. Based upon evidence yielded from two research projects, Presmeg (2002) was convinced that either high school or graduate students' beliefs about the nature of mathematics enable or constrain their capability to bridge the links between everyday practice and mathematical concepts taught in school. While studying the relationship between middle school students' epistemological beliefs and aca-

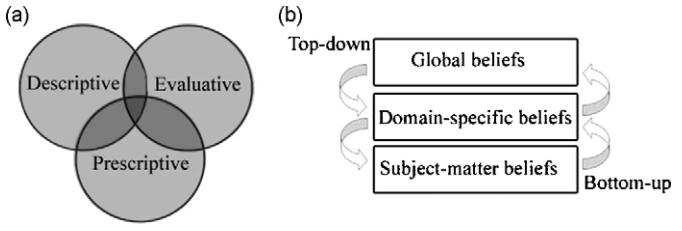

Fig. 1. (a) Different belief components and (b) different belief structures.