FACTORS THAT INFLUENCE COLLEGE STUDENTS' MATHEMATICS IDENTITY AND BELIEFS ABOUT THE NATURE OF MATHEMATICS

FACTORES QUE INFLUYEN LA IDENTIDAD Y CREENCIAS SOBRE LA NATURALEZA DE LAS MATEMÁTICAS DE LOS ESTUDIANTES UNIVERSITARIOS

Parker Parrent
University of Kentucky
parker.parrent@uky.edu

Cindy Jong
University of Kentucky
cindy.jong@uky.edu

William Wiseman
University of Kentucky
william.wiseman@uky.edu

Pooja Sidney
University of Kentucky
pooja.sidney@uky.edu

Benjamin Braun
University of Kentucky
benjamin.braun@uky.edu

Students' beliefs about the nature of mathematics can impact many aspects of their academic and life pursuits and be influenced by a myriad of prior educational experiences. To examine undergraduate college students' (n = 50) past mathematics education experiences, beliefs about the nature of mathematics, and experiences in a College Algebra course, pre- and post-surveys were administered in Spring 2022. The figured worlds conceptual framework was used to understand in the multi-layered components of identity in varying mathematical learning contexts. Results of open-ended responses demonstrated four themes, including: affective factors (e.g., stress, enjoyment, confusion), achievement (e.g., success, failure, course requirements), acknowledgement (e.g., feeling seen, participation) and application (e.g., careers, daily life) of mathematics among undergraduate college students.

Keywords: Affect, Emotion, Beliefs, and Attitudes; Undergraduate Education; Identity

Perspectives

The nature of mathematical knowledge is loosely defined by Kean (2017) as an individual's belief of how mathematical knowledge is organized and the source, justification, and content of this knowledge. Students' beliefs about the nature of mathematics can impact many aspects of their academic and life pursuits and be influenced by a myriad of prior educational experiences. In this study, we specifically examine the beliefs and experiences of college students enrolled in college algebra courses, as we know the course is a gatekeeper that often predicts students' graduation (Bailey, et al., 2010). We use the figured worlds conceptual framework to understand the multi-layered components of identity in varying contexts related to the learning of mathematics (Holland, et al., 1998).

Boaler and Greeno (2000) explore the ideas of students' figured worlds and how they are affected by the classroom environments teachers create. According to Holland et al. (1998), "figured worlds are places where agents come together to construct joint meanings and activities. Figured worlds are socially and culturally constructed realms of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p.52). Students within these figured worlds develop their own positional identities, which is the way in which a student perceives themselves within their own figured worlds (i.e., the contexts in which they participate, such as a college mathematics course or

a work environment), and the actions they take to fit into these roles they have developed (Boaler & Greeno, 2000).

Methodology

Context of Project

To examine undergraduate college students' past mathematics education experiences, beliefs about the nature of mathematics, and experiences in a College Algebra course, pre- and post-surveys were administered in spring 2022. While there were 92 participants who completed the pre-survey and 131 who completed the post-survey, 50 participants completed both the pre- and post-surveys. For the purposes of our study, we decided to focus on this sample of 50 to compare pre- and post-survey results. Our guiding research question was: *In what ways do college students' past and current experiences learning mathematics affect their views on the nature of mathematics?*

Instrumentation

The College Math Beliefs and Belonging (CMBB) survey, which consisted of Likert-type items and open-ended questions, was developed by a collaborative group of researchers in the Mathematics, Psychology, and STEM Education departments at the same university where data were collected. The survey included scales intended to measure beliefs about the nature of mathematics, perceptions of mathematics proficiency, and sense of belonging in mathematics; responses were on a 6-point scale ranging from *strongly agree* to *strongly disagree*. The open-ended questions probed students about past mathematics experiences, experiences in College Algebra, and views on mathematics. In addition to examining the psychometric properties of the scales, researchers conducted cognitive interviews to collect further validity evidence (Leighton, 2017). One open-ended question posed at both timepoints asked participants: *What does mathematics mean to you?* Questions unique to the pre-survey included the following: Describe at least one *positive* mathematics experience from when you were in elementary, middle, and/or high school. (It can be something you experienced in school or out of school.) *and* Describe at least one *negative* mathematics experience from when you were in elementary, middle, and/or high school. (It can be something you experienced in school or out of school.) Questions unique to the post-survey included the following: Have any experiences this semester influenced your view of mathematics? If so, how? *and* Did your experience in this course influence your decision whether or not to take math courses in the future? If yes, how did it influence you?

Data Analysis

For the purposes of this paper, our analysis focused on responses to the open-ended questions in the CMBB. We used open coding by taking an inductive approach to themes that directly came from the data (Strauss & Corbin, 1998). The raw data were organized into a Google spreadsheet and all responses were read. As two researchers read through the raw data, notes were taken of the types of responses being made to inform preliminary codes. This process was repeated as codes were refined and defined. Then, the data were coded by indicating a "1" when a particular code was present within a participant's response to allow for frequencies to be computed. Within each theme, we also coded one of three sub-categories to capture the nuances among the responses: positive, negative, or neither. In some cases, responses had multiple codes and included experiences or perspectives that were both positive and negative. Finally, we categorized the codes into major themes and developed a description for each theme (Creswell, 2009). After the two researchers coded the data, disagreements were discussed and negotiated to establish 100% agreement for the 300 responses (50 participants with three questions at each of the two timepoints).

Results

Four themes emerged from the open-ended responses. Included in these themes were: affective factors (e.g., stress, confusion, enjoyment), achievement (e.g., success, failure, course requirements), acknowledgement (e.g., feeling seen, participation) and application (e.g., careers, daily life) of mathematics. The themes of affect and acknowledgement related to identity while the application related to perceptions of the nature of mathematics; achievement related to both. We also included an "other" category to capture statements that did not fit into one of the four themes. Table 1 provides examples of responses that were coded as one of the four themes. Patterns still need to be examined within and among the frequencies due to several of the pre- to post-questions being different. However, the following frequencies were present among responses in the pre-survey, which included college students' prior learning experiences in mathematics: achievement = 79 (positive = 36, negative = 39, neither = 4); affect = 37 (positive = 19, negative = 18); acknowledgement = 14 (positive = 9, negative = 5); application = 28 (positive = 18, negative = 1, neither = 9). In response to what mathematics means, college students described it as formulas, studying numbers and shapes, ways to solve problems, being difficult, important, and applicable to real life.

Table 1. Sample Responses among Themes based on Open-ended Questions

Theme	Responses
Achievement	Getting all A's in my math classes in high school. My 10th grade geometry teacher didn't really teach us, so I almost failed my first high school class.
Affect	I enjoyed math all of my years because of all of the teachers I had. It makes me feel stressed and that is a requirement not something I should feel like I want to do.
Acknowledgement	One positive experience I've had was in high school when I was in a stats class. I felt appreciated and was able to engage in class/learn. I was told that I have a great memory with concepts compared to other students and remembering the definitions and ideas of certain topics.
Application	Math helped me to be better in physics. I help my grandma to solve the problems in daily life when we buy something in the market.

Discussion

Boaler and Greeno (2000) analyzed figured worlds and mathematical identities by addressing the four ways of knowing as developed by Belencky et. al (1986), which include: received knowing, subjective knowing, separate knowing, and connected knowing. We found that two of these ways of knowing were shown in our undergraduate mathematics context: received knowing and connected knowing. Received knowledge is seen as a type of learning in which the individual looks to an authoritative source for their knowledge. Connected knowing is developed primarily through interactions with people, most of the knowledge comes from understanding other experiences, reasoning and combining that with those of the individual. We plan to further investigate these types of knowing and how they relate to the nature of mathematics and identity

among undergraduate students. Findings further supported the multi-layered and complex nature of identities in mathematics, and how they are shaped by various learning experiences.

References

Boaler, J. & Greeno, J. G. (2000) Identity, Agency and Knowing in Mathematical Worlds. In J. Boaler (Ed.) Multiple perspectives on mathematics teaching and learning (pp. 171-200), Westport, CT: Ablex.

Belencky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). Women's Ways of Knowing: The Development of Self, Voice and Mind. New York: Basic Books Inc.

Creswell, J.W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches (3rd ed.). Thousand Oaks, CA: Sage.

Holland, D., Lachtcotte, W., Skinner, D., & Cain, C. (1998). Identity and agency in cultural worlds. Cambridge, MA: Harvard University Press.

Kean, L. (2017) Using Beliefs about the Nature of Mathematical Knowledge in Teaching College Algebra. In B. Gold, C.E. Behrens, & R.A. Simons (Eds.) Using the Philosophy of Mathematics in Teaching Undergraduate Mathematics (pp.63-74), MAA Press: Washington, DC.

Leighton, J. P., & Ohio Library and Information Network. (2017). Using think-aloud interviews and cognitive labs in educational research. New York, NY: Oxford University Press.

Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage.