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Challenging Students' Beliefs about Mathematics: A Liberal Arts Approach

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Abstract

In this teaching notes article, we discuss our efforts in a liberal arts mathematics class to engender transformative learning regarding students' beliefs about mathematics. Specifically, we report on our overall approach as well as course readings and projects that we believe contributed to this goal. We situate our approach within Mezirow's characterization of transformative learning and coordinate with the mathematics education literature.

Keywords: transformative learning, mathematics education, beliefs about mathematics

Liberal arts mathematics courses at the undergraduate level typically offer an investigation of topics that are designed to engender an appreciation of the interdisciplinarity of mathematics. This broadly defined objective affords instructors a certain flexibility with regards to the mathematical content. However, Schoenfeld (1992) claims that an "appreciation of mathematics," can be an exceptionally difficult belief to instill in students, who tend to espouse (distressingly inaccurate) beliefs about mathematics, including:

- mathematics problems should only be solved in one particular way;
- mathematics is an isolating, solitary activity; and
- school mathematics holds little relevance to the real world.

Mezirow (2003) characterized transformative learning as that which transforms "sets of fixed assumptions and expectations" (p. 58). We decided to exploit our broadly defined course objectives to design a liberal arts mathematics class that would effect transformative learning by directly challenging these assumptions and expectations about mathematics. While this undertaking might seem overly idealistic, especially in light of findings that pre-formed beliefs about subject matter are not easily changed (e.g. Brown, Cooney, & Jones, 1990), there is evidence of liberal arts mathematics courses accomplishing such goals (Szydlik, 2013). In this paper, we describe our overall approach as well as the final project, along with details of one particular student's project that reflects transformative learning about mathematics with regards to the above misperceptions.

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The course was inherently imbued with an interdisciplinary focus, as it was team-taught by a mathematician and a sociologist (the first and second authors, respectively). In alignment with this interdisciplinary focus, the course featured a multitude of reading assignments in popular mathematics books (e.g. Ellenberg, 2014; Silver, 2012) that employ mathematics as a tool to interpret the modern world. Along the same lines, the course emphasized writing assignments as a means for students to interiorize mathematics by "placing the subject in a context that makes sense to them" (Meier & Rishel, 1998, p. 90).

We describe here the final project for this liberal arts mathematics course, an assignment that reflected our overall approach to this course. We sought to design a statistics project that we hoped would highlight a more accurate view of mathematics while still affording opportunities for students to learn the associated statistical concepts. For example, in addition to engendering transformative learning relative to the aforementioned misperceptions about mathematics as a discipline, we also wanted to ensure that students would avoid common errors in data analysis, such as reasoning from a personal opinion rather than data (e.g. Chick, 1999) or using charts as an illustration rather than a tool for data analysis (Ben-Zvi & Friedlander, 1997). This assignment also aligned with calls for students to analyze genuine, real-world data (Garfield, 1995) in which they would have to defend their interpretations (e.g. Cobb, 1999) to their peers.

With these objectives in mind, we designed a project based upon the analysis of genuine data from the General Sociological Survey (GSS) and tasking the students with creating and answering their own research questions using the statistical concepts they had learned[1]. There were 15 data categories reflecting a wide range of social issues for a sample size of 500 Americans[2]. We purposefully designed this assignment to have few specific requirements to encourage students to explore and propose creative, empirically-based solutions for an open-ended problem scenario of their choosing (in the same spirit as the course readings from Ellenberg (2014) and Silver (2012)). Thus, much like such efforts in the real world, there were no specific guidelines for statistical tools to use. Rather, the students would need to select tools appropriate to the objectives they set for themselves. This is not to say that they received minimal guidance, however. Leading up to the project presentations, we provided a week (3 hours) of class time for students to share ideas with and receive feedback from their peers and us.

The results did not disappoint. Students selected and explored topics that they deemed meaningful or interesting, including the relationships between education level and income, collegiate athletes and athletic performance, women in the workforce, and government support of libraries and levels of literacy. Many of these topics were related to the students' respective majors (in the order of the aforementioned topics, the corresponding majors were: elementary education, physical education, sociology, and English) and many students reported that they hoped to continue researching the same topic for their senior capstone project. Representative of sentiments echoed by many students in the class was this summative remark by the English major who investigated a possible correlation between financial support of libraries and levels of

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[1] Because this assignment appeared near the end of the course, the list of topics is quite lengthy: designing and analyzing statistical studies, measures of central tendency, measures of dispersion, probability and confidence intervals, distributions, and multiple linear regression.

[2] These categories included: family income, number of small children, religious attendance, years of education, number of hours spent watching television, and scales measuring happiness, health, conservative views, approval of Congress, approval of spanking children, and depression. These categories were intended to get students started with the project – they were also permitted (and encouraged) to research and use data of their own choosing.

literacy:

> I started this project believing that there had to be a cause and effect going on because it just made sense to me. But the way I approached this project using correlation and linear regression did not really show me what I thought I would see. Everyone else in the class was also surprised when I gave my presentation. There was a small positive trend but I expected it to be much larger. I do not think that this means that spending money on libraries is not important or that libraries do not affect how much people read, but only that the way that I approached it did not help one way or the other. I made sure to write this because I thought that some people might read it and think that libraries weren't important. There are lots more data sources to sample and use and other statistical techniques to use also, which I hope to get into more for my capstone project.

Reading beyond the informal and somewhat disjointed writing style, notice that this remark speaks specifically to each of the three misperceptions students hold about mathematics (as reported by Schoenfeld (1992)) that we noted at the start of this paper. This student certainly acknowledged (1) a multitude of possible approaches to her problem, (2) discussions with peers, and (3) the relevance of mathematics to an important real-world situation. Moreover, this student's response was rather typical (instead of exceptional), which we interpreted as evidence that we had indeed effective transformative learning experiences amongst our students.

We should note that these goals were not achieved from this assignment alone. Indeed, they are goals that we had been feverishly and indiscreetly pursuing since the first day of the course. The final project was the culmination of these efforts. Moreover, as our reports are decidedly anecdotal, we do not submit this report as empirical evidence arguing for this sort of approach (though our results are consistent with rigorous research reports that do—see, for example, Szydlik, 2013). Rather, we hope that this short exposition provides pragmatic, actionable ideas for those instructors seeking to transform their students' fixed assumptions and expectations about mathematics. We believe that the implications of such efforts for students will extend far beyond the mathematics classroom. After all, "one of the tasks of schools is to do their best to teach students to think, and of all subjects none is better suited to this than mathematics" (Dudley, 1997, p. 363).

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