A Case of Community, Investment, and Doing in an Active-Learning Business Calculus Course

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Presented here is a case study of Christina and her goals in an active-learning business calculus course. The larger project, from which this report emanates, involved an instructional redesign of a business calculus course intended to address two main student concerns: (seemingly) irrelevant content and a lack of opportunities to be active in class. Class size mediated Christina's access to community, which she perceived to be a necessary condition for her learning. Additionally, Christina drew a distinction between authentically situated mathematics and pseudo-situated problems that fail to invest her in the problem-solving process. She valued opportunities to do mathematics during class and receive feedback from her instructor and peers. This project has implications for the mathematics education of business students, active-learning in post-secondary mathematics, and situated mathematics problems.

Keywords: business calculus, non-STEM, active-learning, situated mathematics, student goals

Student engagement is undoubtedly an important factor in the learning of post-secondary mathematics. As business calculus instructor, I especially struggled to develop and foster student engagement. Furthermore, students in this course considered the content to be irrelevant to their lives and futures. Business has long been the most popular post-secondary bachelor degree awarded in the United States (National Center for Education Statistics, 2015). Given the large student population associated with business calculus and the value of mathematics proficiency in society, addressing issues of student engagement and perceived irrelevant content in this course is critical. Aptitude in mathematics is a powerful societal tool regardless of students' trajectories. This project aims to contribute to existing research in the area of teaching business mathematics and hopes to emphasize the importance and value of the mathematics education of non-STEM students.

Research Questions

The case presented in this report was part of a larger study which examined student agency in a business calculus course. A more detailed description of that study, its context, and methods is described elsewhere (Higgins, 2017). In the larger study, an operationalized understanding of an individual's achievement of agency was the resistive or supportive moves one makes in response to structure. Structure was defined as the set of forces that constrain or enable an individual's goal. Thus, to examine a student's achievement of agency in the context of this course, it was necessary to first determine that student's goals in this environment. This report focuses on the identification of a particular student's goals in this course. The goals of students in a mathematics course influence their engagement with mathematics and their behavior in the classroom. An instructional design informed by the intentions and ambitions of students in a mathematics course can leverage this information to better align the goals of students and instructors.

My instructional redesign of this course that was intended to address student concerns of passivity and irrelevant mathematics in this course. Given the time and curriculum constraints of this course at this institution, how could an instructional design address these student concerns?

1. What can an active-learning business calculus course designed to address student perceptions of irrelevant content and passivity look like?
2. What are the goals of a student in an active-learning business calculus course?
3. What elements of an active-learning instructional design facilitate or constrain these goals?

The results from this study inform the practice of teachers who value student goals in this context and have research implications for the mathematics education of students majoring in non-STEM fields.

Theoretical Perspective and Implications for This Study

My theoretical perspective is rooted in sociocultural theory and draws on Lave and Wenger's (1991) model of situated learning. From this perspective, learning is conceived of as a process of apprenticeship. Experts model practices for novices and gradually include novices in increasingly legitimate participation in the community. Novices learn through both modeling and doing. Within a business calculus course, I am positioned as an expert in mathematics, however these students are explicitly not apprenticing into a mathematics community. In the larger and perhaps more relevant context of their academic majors, these students need to be apprenticing into a community of schooled businesspersons. This influenced my instructional design and motivated me to include more real-world problems and contexts that students might encounter in a business career.

Literature Review

Business Calculus

There is currently a striking gap in mathematics education literature regarding calculus courses for business students (Mills, 2015). Considering that business is the most popular undergraduate bachelor degree awarded in the United States (National Center for Education Statistics, 2015) and that many institutions require business majors to take courses through mathematics departments, this paucity of research is alarming. Due to the motivations and career goals of business students, there are many issues specific to this population that are not shared by students in a traditional calculus course. An intention of this project is to contribute to this area of research and highlight the importance of this student population and their mathematics education. In 2000, the Curriculum Renewal Across The First Two Years (CRAFTY) subcommittee of the MAA released a report that included recommendations for addressing needs unique to business students enrolled in mathematics courses (Lamoureux, 2000). Given the situated nature of businesspersons' actual use of mathematics, problems and associated decisions encountered in the real world are naturally coupled with significant ambiguity. This team recommended that this ambiguity be reflected in the problems included in mathematics courses for business students. Pedagogically, this report suggested including opportunities for student discussion of problems during class, invitations for students to present solutions and justifications to the rest of the class, and emphasized the importance of making relevant mathematics explicit. Given that these students are apprenticing into the world of business, a social industry, group work can help develop important social skills that are valued by employers. In this vein, student assignments should reflect the same material and scope that they might submit to a superior in the workplace. This report noted that mathematicians typically lack the resources to create valid and appropriate business-contextualized problems. Increased communication between mathematics and business faculty regarding mathematics courses for business majors would work toward solving this issue.

Active-Learning Strategies

The literature on active-learning strategies is consistent and indisputable. Research indicates that these practices are linked to significant positive learning outcomes in students. Freeman and colleagues (2014) conducted a meta-analysis of research on active-learning and its effects on students in STEM courses and their learning. They found that for students who were in courses with at least some active-learning, student performance increased by nearly half a standard deviation when compared to student outcomes from a traditional lecture course. Additionally, students in lecture-style courses were more likely to fail than students taking courses that incorporated active-learning. Freeman and colleagues concluded that active-learning positively affects student performance in STEM courses at the post-secondary level. In 2016 the Conference Board of the Mathematical Sciences published a statement calling for an increase in active-learning strategies in the teaching of post-secondary mathematics (Braun et al., 2016). This statement advocates for the inclusion of active-learning techniques to provide students with meaningful mathematical experiences and as an avenue for modernizing the instruction of mathematics at the post-secondary level.

Methodology

As stated previously, this report was part of a much larger project that involved a significant amount of pilot work including interviews with both business and mathematics faculty, interviews with students currently enrolled in the business calculus course at this institution, and a pilot version of my course re-design during Summer 2016, accompanied by interviews with students in this course. My course redesign included four intentional elements: daily reviews, in-class group activities, readings, and punctuated lecture style. Daily reviews were ungraded problem sets distributed at the beginning of each class that reviewed the content from the previous class and typically included a conceptual question and a few procedural problems. Student were encouraged to work on these problems with their peers. I circulated through the classroom answering both group and individual questions. After 10-15 minutes, we went over the solution as a class. Six in-class group activities coincided with application sections and foundational sections in the curriculum. Students split themselves into groups and worked through the problems during the class period. Each activity was also accompanied by a reading outside of class. These readings included motivation for the topic covered in the activity, an explanation of the concepts underlying the mathematics, the mathematics used to solve the problem, and a fully worked-out example problem. Students were required to digitally annotate each reading prior to the corresponding activity day. In order to allow for more time for students to be active, I was interested in eliminating lecture-style instruction as much as possible. The curriculum in this course covered a tremendous amount of content, which created challenging time constraints. Rather than resorting to direct instruction, I adopted a punctuated lecture style that encouraged students to participate routinely. I regularly asked students questions during instruction and included frequent opportunities for students to try problems on their own, work on problems with their classmates, or discuss questions with their classmates. These times generated ways for students to be actively engaged during instruction.

Main Study

Student make-up. My business calculus course during Fall 2016 began with 51 students and ended with 50 students (one student withdrew from the course after approximately ten weeks). This was a reduced class size that required permission from the department chair. This course typically enrolls approximately 90 students in each section. There were 20 female students (19 after one student dropped) and 31 male students. There were nine freshman students, 20 sophomores, 18 juniors, three seniors, and one post-baccalaureate student. There were 43 students majoring within the college of business, four students majoring in economics, and four students whose majors were listed as either "exploring" or "undecided".

Selection of participants. This report focuses on one of my participants, Christina. She was initially selected to be part of the larger study because she appeared to be an exemplar of a very actively engaged student. Given her high level of engagement in the course, I was surprised to learn that Christina was retaking this course. She had previously taken business calculus in Fall 2015 and earned a D. Ultimately, Christina earned a B in my course. I was particularly interested in learning what her goals were in this course and the elements of my instructional design that facilitated or constrained these goals.

Data Collection. All class sessions were video and audio-recorded, save a few due to user error. The six videos of the in-class activities were completely transcribed (the first and second activity transcriptions contained less information due to missing recordings). In addition to the video and audio-recorded class sessions, a minimal amount of student work was collected for the larger study.

After the course ended, Christina participated in three interviews. The first interview involved her history with mathematics at the university level. This interview also helped me initially determine what her goals in this course were and what aspects of the design of our Fall 2016 business calculus course influenced those goals. The second interview was intended to validate things that I had inferred from the first interview. This involved confirming Christina's goals and the factors that influenced these goals. By our third interview, I had written a description of her goals in the course. This interview was meant to answer any remaining questions I had about her goals as a student in this course.

Analysis. To identify Christina's goals in this course, I began by writing a description of her experiences with post-secondary mathematics, primarily based on our first and second interviews. After the initial, general description of Christina and post-secondary mathematics, I composed a detailed summary of Christina as a student in our business calculus course, again mostly from our first and second interviews. These characterizations enabled me to both explicitly determine Christina's goals and identify characteristics of my instructional design that Christina perceived to be constraining or enabling. From these influential forces, I backward-inducted the goals that these affected. Once I had identified Christina's goals associated with this course, I coded all three of her interview transcriptions for these goals. These codes were used to perform a second coding pass, where I identified instances in our interviews when Christina referred to structural elements in our course. These codes were used to verify and justify claims made in her case. From the sets of goals and associated structural elements that I had identified, I described what Christina was a case of, her goals in the course, elements of our course that facilitated or constrained those goals, and the actions she took towards the progress of those goals.

Christina: A Case of a Student Valuing Community, Investment, and Doing

Classroom Community

Size of class was an important factor for Christina[1]. The first business calculus course in which she was enrolled consisted of approximately 80 students. During our first interview, she discussed her struggle to form working relationships with her classmates and connect with the instructor in that course. Christina uses her relationships with her classmates to secure feedback about her understanding of topics and to establish her belonging in a course: "It's just so not personal and I can't learn the same way. I feel like I'd be terrible in online classes because I need that interaction. And so, in some classes I am very involved, but other classes not." She explained in our interviews that she would have been much less likely to ask questions in our course if she had not formed a friendship with the student who sat next to her, Andy. Not only did she use this relationship to solicit feedback from Andy, she also explained that establishing a friendship in the class made her more comfortable asking questions and being honest about her misunderstanding. A sense of community is an important factor in the ways in which Christina advocates for her own learning. She is much more likely to act in ways that serve her other course goals if she has established relationships with other classmates and the instructor. Christina observed that the size of class affected her access to community, which is a mediating factor for advocating for her own learning. Regardless of instructor ability or effectiveness, in a large class, she perceives her learning to be inhibited. In this way, class size affects her ability to find community in a mathematics course, and a sense of community affects her successful achievement of agency.

Contextualized Mathematics versus Pseudo-Situated Mathematics

Contextualized mathematics problems help invest Christina in the problem-solving process and connect mathematics to real-life issues, which motivates her to work to understand the solution process. When I asked her about the readings in our course, Christina drew a distinction between problems contextualized in real-life scenarios and problems that are pseudo-situated:

> Yeah, I think a lot of them had actual stories, like things that would actually happen in real life. And that's really helpful. Because a lot of math is a lot of numbers, so when you put words in there – I always hate math word problems. But if they're actually relevant and you're like, 'Ok, I'm understanding. Ok, this would happen in real life,' or like, 'This is something that does happen,' versus, I don't know, like apples and whatever. You know what I mean?

Being able to identify with a problem and recognize it as a valid real-life predicament invested Christina in the solution process and motivated her to focus and value the problem-solving process. Relevant problems motivated her to learn the material because she saw a potential future benefit for her in her career and she identified this connection between school mathematics and real life as a helpful force in her understanding of the material.

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[1] The quotes and claims in this section come from transcriptions of interviews conducted with Christina.

Opportunities to do mathematics in class

Christina noted that our course offered frequent opportunities to do mathematics during class. She especially valued this so that she could self-assess her knowledge and receive appropriate feedback. In her words:

> So when we're in class and you're making us do what we would be doing for homework and then you're there to ask – to help us if we need questions, that was really helpful for me, because sometimes I don't know what I don't know until I'm already home. And then I can't – it's harder to email about a question than it is to just ask in person.

She observed that this characteristic of our course was unique in comparison to her previous post-secondary mathematics courses. Prior to our course, she had mostly spent class time watching mathematics happen, rather than doing mathematics herself. Working through problems during class gave Christina an opportunity to address misunderstandings during class time and with the instructor or her peers. Opportunities to try problems, discuss with her classmates, and receive feedback from her instructor were greatly valued and noticeably used by Christina to aid in her learning.

Discussion and Implications

Real-Life Versus Pseudo-Situations

By the time students in this course reach higher education in the United States, they have a somewhat defined career path. To only include problems that are inherently procedural in nature, such as the pseudo-situated problems to which Christina referred, is a failure to serve our students. Problems situated within a business context should be an inherent characteristic of a business calculus course. Rather than trying to find how business situations can fit into the calculus curriculum, instructors should be focused on how calculus can fit into business contexts.

Business Education

As referenced in the MAA CRAFTY (Lamoureux, 2000) recommendations, business solutions in the real world are often messy, ambiguous, and fail to adhere to procedures prescribed by school mathematics. Given this phenomenon, instructional practice in a business calculus course should reflect this same ambiguity. The mathematics education for these students should model, in some regard, the situations they will encounter in their career. Mathematics instructors are not typically experts in real life business situations. In order to effectively incorporate these kinds of problems and data sets, mathematics instructors need to collaborate with business faculty and with businesspersons working in industries.

Research and Teaching Implications

Business calculus instruction and course design. Christina's experiences in this course suggest that opportunities to be active in class are valued by students. Student populations are dynamic and it is the onus of instructors to evolve our practices to best meet their needs. Opportunities for interaction with other classmates and with the instructor were conspicuous in this course. Past post-secondary mathematics courses in which Christina was enrolled allowed for little student activity. Christina considered interaction with other people to be a necessary condition for her learning. This finding is consistent with current research on active-learning in post-secondary mathematics courses.

Real-life business problems and data sets. The case of Christina illustrates that students in this course value problems that are contextualized in real-life situations and that students develop a stronger investment in solution processes when problems are situated in relatable contexts. The students in a business calculus course are not typically STEM students and most do not enter this course with an intrinsic interest in mathematics. They are majoring in a social field and are aware that their careers will likely involve working with other businesspersons. This finding is consistent with the recommendations from the MAA CRAFTY subcommittee.

Non-STEM post-secondary mathematics education. Recently, mathematics education has included a strong focus on the mathematics education of STEM majors. Like Mills (2015) reported, there is a striking lack of literature on calculus for non-STEM majors. This project examined student experiences in a non-STEM post-secondary mathematics course and contributes to the existing literature on calculus as a client discipline, mathematics education for business majors, and post-secondary mathematics education for students majoring in non-STEM disciplines. Mathematics courses for students in non-STEM disciplines encompass issues of motivation, relevancy, and confidence. While mathematics education for STEM students is clearly a significant issue, the lack of literature on calculus for non-STEM majors might suggest that these are not important issues. Despite this dearth of literature, I imagine mathematics educators and researchers would all agree that these student groups and their mathematics education are as valuable as any other student group. However, it is indisputable that non-STEM students are underrepresented in post-secondary mathematics education research. This underrepresentation is especially troubling considering that business is the most prevalent bachelor degree awarded in the United States. While this project hopes to contribute to the existing literature, there is a desperate need for more research in this area.

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