Re-Humanizing Assessments in University Calculus II Courses

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Answering the call of Francis Su (Su, 2017) that "math is for human flourishing" and a challenge by Rochelle Gutiérrez to rehumanize math (Gutiérrez, 2018), I changed assessments in two university calculus II courses. The traditional way to change assessments is to change the questions, either by type or by content. Instead, I focused on changing/rehumanizing the structure of exams to include small group discussions between students for part of the exams. This assessment change, along with a consistently enacted classroom mission statement, produced higher exam scores and improved student engagement. Through surveys, focus groups and interview data, students also reported feeling they had a deeper understanding of concepts, as well as a humane and positive math experience in a math class they thought was very difficult.

Keywords: calculus, assessment, rehumanizing, engagement

Objectives/Purpose and Theoretical Framework

Mathemaphobia was first coined by Sister Mary Fides (Gough, 1954), who taught high school mathematics for years and was concerned about students who experienced anxiety in learning mathematics, with a pronounced increase in anxiety during exams, that then impacted their attendance and interest in mathematics and school. This phenomenon was later coined simply as math anxiety (Tobias, 1978), with studies showing correlation between math anxiety and test anxiety (Hembree, 1990). More than 50 years after the idea of mathemaphobia was introduced, we continue to grapple with this problem (Perry, 2004). It is still true that in most math classes exams tend to be high-stakes, since they substantially impact the grade a student receives and grades tend to be how many students (and society) measure success. Additionally, even for college STEM majors who do not have a general fear and loathing of mathematics, as Marilyn Burns called it (Burns, 1998), some of them may experience anxiety on math exams (Perry, 2004).

Knowing that math anxiety is a serious issue, a variety of solutions have been proposed, including both behavioral-related methods and cognitive treatment (Hembree 1990; Perry, 2004). A recent direction comes from ongoing discussions about math education and equity. Within the last year, Rochelle Gutiérrez has coined the term "rehumanize mathematics" (Gutiérrez, 2018), issuing a call to action to bring a more humane element into the classroom by focusing on practices and curriculum that better serve typically underrepresented groups of students. Similarly, another call for a focus on rehumanizing mathematics comes from a mathematician who, in his closing talk as he stepped down from being MAA President, called on mathematicians and math educators to remember that mathematics is "for human flourishing" (Su, 2017).

While there are many ways to implement such goals of rehumanizing math, one potentially impactful leverage point is to focus on assessments as a known stressful and high-stakes part of a math course. Theses changes were implemented in a college calculus II course where I was the

instructor of record and thus this is an example of teacher-researcher research. (Schoenfeld & Minstrell & van Zee, 1999; Zimmerman & Nelson, 2000). My goal in enacting these changes with my exams was to answer the call to rehumanize mathematics by playing the game called mathematics and also changing the game (Gutiérrez, 2009). It was to answer the call to "find a struggling student, love them, be their advocate" (Su, 2017). It was to increase students' sense of belonging in their mathematical pursuits.

One important research question I'm exploring is: how does a rehumanizing-math approach to assessment in a large calculus 2 class impact exam scores and student learning?

Methods

I drew on my previous knowledge and experience regarding mathemaphobia and exam anxiety; then combined that knowledge with the current call for change. Thus, I decided to change the structure of the exam and not the content of the exam. I attempted to rehumanize mathematics in my calculus II classrooms by decreasing test anxiety and increasing student interaction, to build a community rather than a competitive setting. Research has shown the importance of discussion for increased comprehension and a positive impact on learning (Roschelle, 1992; Engle & Conant, 2010). Thus, I wanted the students to have access to mathematical discussion during exams to help showcase their knowledge. This change was made in two sections of a high-enrollment calculus II course at a large public research institution. To explore what impact this change in assessment structure had on my calculus II students, I looked at their exam grades over the semester and their final grades, as well as qualitative data from surveys, focus groups and interviews.

In my efforts to rehumanize the classroom and create a cohesive community of learners, every day in my classes, we have the class mission statement written on the board. "This is a kind, inclusive, brave, failure-tolerant classroom." The goal is to consistently remain in the conversation of kindness and to enact this statement every day in class, holding all students, TAs and instructor accountable for this work.

The three midterm exams were each split into two sections, one was a group portion of the exam (worth 32-36% of overall test score), taken during one class, and the other was a solo portion of the exam (worth the other 64-68% of the overall test score), taken on the next class day. The groups were created semi-randomly about 1-2 weeks before the exam. Each group contained three students (or possibly four). Each group portion of the exam contained some of the statistically hardest questions (based on years' of exam data). This encouraged the students to discuss and defend their answers during the group exams. Each student turned in their own group-portion of the exam.

During the group exam, students had 15 minutes to work on their own (silent-solo) and then the remaining 40 minutes to discuss the problems within their group. This way, each member of the group had time to process their ideas and actually solve most, if not all, of the problems on that part of the exam first, and then in the group discussions, everyone had something meaningful to contribute. For the silent-solo portion of the midterms, it was a usual testing structure where each student worked on their own.

The two-hour final exam was one intact exam, not in separate parts. The first 45 minutes was silent-solo, the next 30 minutes was group discussion time, and the last 45 minutes was silent-solo again. This enabled students to work on most of the exam by themselves and then discuss

some of their ideas/solutions within their group, get ideas to help them get unstuck, etc. Then, they had time to finish the exam on their own.

Research data consists of (a) three different surveys students filled out throughout the semester which gave information about their attitudes, as well as feedback about their interpretations regarding rehumanizing the classroom, (b) focus group and interview data, and (c) grade data, all from my spring 2018 calculus II courses. Additionally, I taught a high-enrollment calculus II course in the fall of 2017, and the grade data from that class is being used as control group data, since their exams were the standard exam structure.

Data Analysis and Results

Grade Data

Table 1. This table shows the basic statistics from two semesters of Calculus II courses. Fall, 2017, Calculus II course had no change in assessment. Spring, 2018, Calculus II courses had group-portion of exams implemented.

Fall, 2017	Midterm 1	Midterm 2	Midterm 3	Final Exam	Final Scores
mean	79.6	64.4	73.7	82.5	81.9
median	85	64	77	86.5	84.2
stdev	18.6	21	22.8	16.5	15.8
low	24	8	12	7.5	19.38
high	106	106	107	103.5	104.34
n	169	157	151	144	144

Spring, 2018	Midterm 1	Midterm 2	Midterm 3	Final Exam	Final Scores
mean	80.9	80.4	85.8	91	88
median	84	81	88	93	89.36
stdev	14	14.5	13.3	9.6	8.6
low	47	44	38	58	61.94
high	105	106	106	104	102.85
n	167	166	162	156	156

Table 1 and Figure 2 show the statistics comparing exam scores from fall of 2017 (the control group), before implementation of the group portion of exams, and spring of 2018 (comparison group), after implementation of the revised assessment structure. The results show that, in my aim to give students a more humane mathematical experience than a traditional math classroom provides, the spring 2018 scores on three midterms, final exam and final course scores are all statistically higher than the fall 2017 data. Perhaps more interestingly, the standard deviations went down substantially with the new exam structure. (Note: no other changes to the courses were made between the two semesters.)

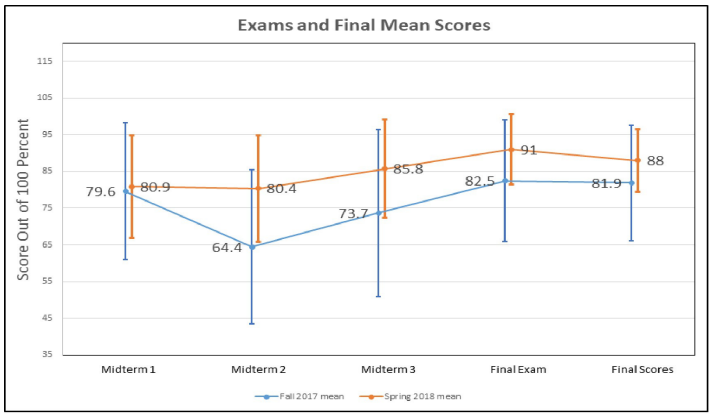

Figure 2. A line plot showing the same data as in Figure 1, with only the means (as points) and standard deviations (as error bars at each point) present in this graph.

The positive impacts of assessment changes were furthermore evident in the lowest exam grades, which were notably higher, suggesting that the changes helped students at the bottom of the class while also supporting students in the mid-performance range. For the top 10% of performers, there wasn't much difference in the statistics. Thus, this new exam structure does appear to either benefit students' grades or have a ceiling effect for the high performers' grades.

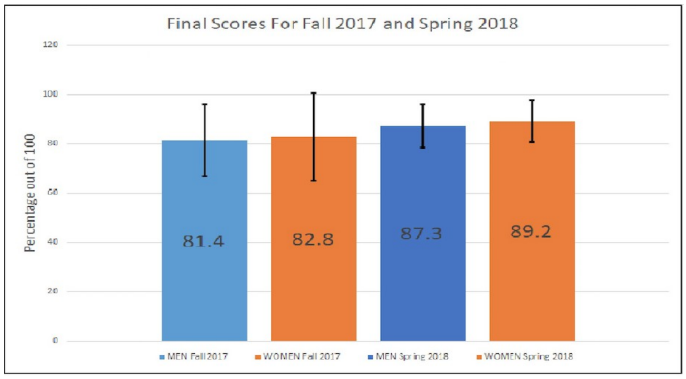

Figure 3: This table shows the final score statistics broken down for each of the two semesters, for men and womxn. (Note: I've chosen to use womxn to denote all students who identify as either female, gender fluid or non-binary.)

In Figure 3, you can see the grade data, for only the final scores, across the two semesters for both men and womxn. Statistically, the grades went up for both groups of students. However, the standard deviation for the men basically stayed the same and the standard deviation for womxn went down surprisingly with the new exam structure.

Survey/Focus Group Data

For the survey data, unique codes were created from within the data and will be revised iteratively. So far, I've gone through the focus group and interview data with one pass, focusing mainly on patterns of comments and have not yet coded it iteratively.

Recurring themes of (a) less anxiety experienced during the exams and (b) a community feeling in the classroom, in both the survey comments and the interview/focus group data, is captured by the following student quotes:

> I feel like being able to start an exam by discussing the concepts and work with other students helps me do better on the solo portion and *eases the nerves a bit*.

> I really think the group structure *helps both those who are doing great and otherwise*. Explaining math and understanding it both *require cooperation* in my opinion.

> The group portions are excellent, for me I have a tough time starting choosing the methods or test, but *after I discuss with other I gain a better understanding* of which one and why and then I can go forth with my process and usually *complete it on my own*.

The group exam structure not only positively impacted the grades, statistically, for the students, but it also helped build a community inside the classroom where students felt less anxious and more able to pursue mathematics as something to practice and make mistakes, as opposed to something they must be perfect at.

And, finally, when looking through the survey answers to a question about how students

interpret or define the idea of re-humanizing mathematics, I see a recurring theme of having a humane classroom environment initiated and enacted by the teacher, as well as the students, as one path to a rehumanized math experience. Here are a couple student quotes that epitomize that theme.

> In my opinion, the idea of 'Re-humanizing mathematics' seems to be the idea of *making math less robotic, cold and conspicuously heartless*. I think the problem is less making math more human, and more *getting people to see that math IS human*. I think teachers could move towards this goal of 're-humanizing' Mathematics by *helping their students see that it is not a 'genius subject'* that only someone with a computer for a brain could do, and that *Mathematics is actually a really fun, cool subject invented by humans to help us with our everyday lives*.
>
> I think teachers/educators can re-humanize math by *making better learning environments* in class, and by *learning how to connect better with people*.
>
> I would like to think this has to do with *framing math practice and math learning as a human endeavor, recognizing how it is connected to other human undertakings, and subject to some of the same biases and flexibilities, instead of being presented as sanitized, rigid, and binary* by necessity. I think that *the way we talk about math in classrooms can influence student receptiveness, and therefore, influence student engagement and comprehension*. If students just feel like they are in class to intake a litany of procedures and formulas, and then to be assessed by reproducing them, mathematical thinking will stay relegated to one portion of their mind, and not interact with other ideas that students may simultaneously processing.

Significance

The group structure of part of the exams more closely mimics how mathematicians actually work, compared to the usual silent-solo style of examination. Mathematicians talk to each other when they're stuck on a problem. Then, they go back to work on the problem by themselves. Allowing students to discuss mathematics on high-stakes exams, defend their solutions to one another and bounce ideas off of someone else when they get stuck allows them to show what they truly know without having test anxiety get the better of them. I argue that this exam structure more authentically assesses student calculus knowledge than silent-solo exams.

Mathematics, as an intellectual pursuit, can frequently feel hostile for students. Many classrooms feel like such a competitive environment that students don't even want to ask questions in class for fear of being told they're wrong or incompetent or unintelligent, and even if we educators don't explicitly say those words, that sentiment is too often portrayed to students (Jackson & Leffingwell, 1999). I argue that this new exam structure, along with the repetition and enactment of the class mission statement, created precisely the type of classroom where students felt a sense of belonging.

I answered the theoretical call to rehumanize the classroom by boots-on-the-ground changes in assessments that produced overwhelmingly positive results. This structure engendered a kind, humane classroom, where students flourished doing mathematics. And, this structure can be replicated to increase the humanity within mathematics classrooms on a broader scale.

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