The Impact of Personally Relatable Problems to Garner Student Buy-In in Mathematics

Christopher Fisher, David Harness, Andrew Plucker

This paper was completed and submitted in partial fulfillment of the Master Teacher Program, a 2-year faculty professional development program conducted by the Center for Faculty Excellence, United States Military Academy, West Point, NY, 2018

Background/Overview

Many challenges are associated with students being able to relate with teachers. One of the biggest challenges of teaching at the college level is presenting material in such a way that not only motivates students to learn, but in a way that promotes the conversion of short term memory to long term memory. Peter Brown, Henry Roediger, and Mark McDaniel capture the essence of transferring knowledge learned into long term memory in their book, “Make It Stick.” They discuss best practices by successful learners and ways in which students can effectively study various genres of material. They further their discussion to highlight tips for how teachers can facilitate a conducive learning environment through a myriad of best practices and experiential advice. One particular piece of advice Brown, Roediger, and McDaniel offers is to “space, interleave, and vary topics and problems covered in class.”

Calculus, at the college level, presents many students with immense mathematical challenges. The subject of calculus is often celebrated as being “one of the greatest intellectual achievements of western civilization.” Despite its fame and problem-solving supremacy, research shows that “students struggle to succeed in calculus courses and even successful calculus students often fail to use calculus concepts to solve non-routine problems.” When trying to counteract this, teachers often struggle to relate to their students when teaching mathematical concepts, particularly higher level mathematical concepts such as calculus.

Research shows that students learn and comprehend material better when they are active, as opposed to passive, in the classroom. While many active learning strategies exist, some strategies may be best for only a unique set of topics. When learning mathematics, for example, putting pencil to paper to work out a problem is one of the best ways to think about the concepts within the mathematics. A teacher who watches a student work out a problem in a calculus class can see the areas of the math the student is struggling with and which concepts the student may need clarified.

When assigning problems for students to work in calculus, teachers must consider which problems are going to unpack the most theories and concepts that are essential to understanding the material. While calculus textbooks are full of problems that undoubtedly get at key concepts, the problems are often mundane and have little to no relatability to the students. For example, many problems in calculus deal with rates of change and continuous functions. The textbook problems for students to work through revolve around modeling the ways in which particles move. Subsequently, students do not see the applicability of the material they are learning when the problems deal with things like particles. The ability to see the application is one of the many limiting factors that students have when learning mathematics. To foster an exciting classroom environment, teachers must be able to

2 Ibid.
4 Ibid
assist students in seeing the application in order to draw the mental connections needed to understand material at a deeper level.

Problem Statement

This project wrestles with the way in which teachers, particularly in a calculus course, can deliver material while giving students the opportunity to actively learn. With specific regard for teaching calculus, we want to look at whether personally relatable problems impact students’ comprehension, motivation, and performance in calculus. Teachers have the opportunity to express their personalities and give as much or as little information about themselves to their students as they wish. Teachers who can find ways to connect with their students through personal stories or anecdotes can converse with their students on multiple levels.

The specific nature of this project is to determine whether calculus problems that provide a personal narrative of the instructor can influence a student’s learning. We consider student performance, interest, and motivation to qualitatively and quantitatively consider whether these questions maintain any level of significance for student learning.

Methodology

We identified six sections of MA104 (Introduction to Calculus) for implementation of the test. Thus, a total of 97 students comprised the study. This allowed for possible comparison with 52 other sections of MA104 (Introduction to Calculus) students. In total, approximately 850 students were taking MA104 in the applicable semester. In order to establish a baseline, we gave students in the test sections an initial survey to identify a propensity to learn from lessons and questions that were founded on a personal or family situation or problem. The questions had two foci: one asking what style of teaching and learning Cadets preferred and one asking questions about the particular instructor. Previous to the survey, each instructor provided personal information that was subsequently asked in the survey (questions 7 and 8). The questions presented in the survey were as follows:

1. My favorite instructors
   a. Spend time in class relating to me personally.
   b. Stay focused on the material.
   c. Tell military stories!
   d. Provide lots of real world applications for the material.
2. I am
   a. A morning person
   b. Not a morning person
3. I consider myself
   a. Not a math person.
   b. A math person.
   c. Indifferent towards math.
4. Which of the following helped you learn material the best in MA103?
   a. Board problems
   b. Following instructor examples in class
   c. WebAssign
   d. Problem sets
   e. Studying for exams
5. What topic did you enjoy most in MA103?
   a. Single variable DDS
   b. Intro to Calculus
   c. Networks
   d. Multivariable DDS
   e. I did not enjoy anything about MA103.
6. If MA104 was not required
   a. I would still take it.
   b. I would not take it.
   c. I might take it.
7. How many kids does your instructor have?
   a. 1
   b. 2
   c. 3
   d. 4

8. What is your instructor's hometown?
   a. Albany, NY
   b. Casper WY
   c. Walla Walla, WA
   d. Louisville, KY

9. If I was in charge of MA104, we would spend our classroom time…(free text)

We conducted the test over three weeks. In the standard MA 104 course, students were assigned homework problems for each major lesson. Some of these problems were word problems that required students to use and display particular calculus skills applicable to the lesson. Such problems dealt with the typical science / mathematics style questions. That is to say, they involved nondescript individuals tossing balls, driving cars, or propelling particles. In the test sections, each instructor altered two questions a week, adapting them so that they involved a family member performing an activity or some other personal aspect that we hypothesized was of interest to the students. We provided the problems to students the night prior to the lesson being taught, which was typical for the entire MA104 course. During class time, the instructor expounded on the situation to provide a personal touch to it. Instructors also showed students one or more photographs of the family member doing the activity, and often they showed a video. For example, one standard problem assigned to the MA 104 cohort was as follows:

If a ball is thrown into the air with a velocity of $40 \frac{ft}{s}$, its height in feet $t$ seconds later is given by $y = 40t - 16t^2$. Find the average velocity for the time period beginning when $t = 2$ and lasting 0.5 seconds.\(^6\)

One instructor adapted this problem to say the following:

Clara has been practicing her throwing technique (a lot of trial and error). In this particular throw, I determined that the height of the ball (in inches) as a function of time, $t$, could be modeled by the function: $y = 30t - 16t^2$. Find the average velocity for the time period beginning when $t = 1$ and lasting 0.5 seconds.

During class, the students revisited this problem, which was accompanied by a video showing his daughter Clara practicing her throwing technique.

Image 1: CPT(P) Plucker's daughter.

---

\(^6\) James Stewart, *Calculus: Early Transcendentals*. (Boston: Cengage Learning, 2016), 82.
Upon completion of the three week period, students were asked to take a survey designed to determine how much the use of personal stories helped in their learning. The survey consisted of eight questions which asked the following:

1. I felt that Block I was…
   a. relatable.
   b. not relatable.
2. Agree or disagree: the material in Block I has real world application.
   a. Agree
   b. Disagree
3. How much did you enjoy the material in Block I?
   a. Loved It.
   b. It was ok.
   c. Hated it.
4. How useful did you find the “Personal Problems”?
   a. They were very helpful.
   b. They were somewhat helpful.
   c. They were not helpful.
5. What topic did you most enjoy in Block I?
   a. Functions
   b. Rates of Change
   c. Basic Derivatives
   d. Chain Rule
   e. Implicit Differentiation
6. Which do you prefer: the “personal problems” or the types of problems found in the textbook?
   a. Personal Problems
   b. Textbook
7. What is your feedback on the “personal problems”? (free text)
8. If you could change one thing about MA104 thus far, it would be… (Free text)
Analysis

A few different metrics were used to examine the effectiveness of the personal/family problems. The most obvious test was to compare the grades for the Written Periodic Review (WPR) covering the block where the problems were used. Several relationships were examined between the pre-survey, post-survey, and WPR scores. As expected, many factors proved to be unrelated, but a few interesting relationships were observed.

The first interesting relationship was between the type or problems students preferred (personal/family or textbook) and how they performed on the WPR. Figure 1 shows the WPR scores (out of 200 points) for students based on their preference for the personal/family problems verse the textbook problems.

![WPR Grades by Problem Type Preference](image)

Interestingly, students who preferred the textbook problems outscored the students who preferred the personal/family problems. There are a few possible causes for this. First, although the content of the two problems was virtually identical, the textbook problems tend to be written in a more nebulous manner, sometimes making them harder to interpret. Students who prefer interpreting the textbook problems are likely stronger mathematically. Additionally, questions on the WPR were written more similarly to the way the textbook problems were written, so in terms of knowing how to read a problem, students who prefer the textbook problems may have been better at interpreting the questions found on the WPR. It is important to note here that all students were provided with both textbook and personal/family oriented questions, so no students were given any kind of advantage or disadvantage in this regard; this is only a relationship between students’ preferred type of problem and their WPR score.

Another interesting relationship was between whether or not students believe that material has real world applications and their WPR score. On average, students who believed the material has real world applications scored 17 points higher than those that did not (nearly a full letter grade), depicted in Figure 2. This is not a shocking result, since students with a better understanding of the material are probably more likely to understand how it has real world application. Still, the significance of the difference was a little surprising. Also, since the material covered does, in fact, have real world applications, it displays the importance of emphasizing how material can be applied to students in a way that they can internalize. In other words, there is no reason that any student should, after completing this block of instruction, believe that the material has no real world application.
Perhaps one of the most interesting conclusions drawn from this work was the strong positive feedback given to the personal/family oriented problems. In a free-text question which asked “What is your feedback on the ‘Personal/Family Oriented’ problems,” 85% of students gave positive feedback, 6% gave neutral feedback, and only 9% gave negative feedback. Most of the positive feedback focused on how the problems were fun, helped students relate to the instructors, and gave them a break from the “monotony” of the textbook. Only a few of the responses to this question actually dealt with whether or not the problems actually helped the students learn the material at hand better than the textbook problems. It is important to note that there was no evidence that this positive attitude towards the problems actually impacted the students’ understanding. This does not mean that the result is meaningless, however. Even if it does not directly impact test scores, having students enjoy (or at the very least “dislike less”) being in class and working on problems is definitely a positive result, as it can lead to students being more open to further study on a topic which they may otherwise be uninterested.

Another interesting results is that students’ response to the personal/family oriented problems was completely independent of whether or not students indicated that they prefer that teachers relate to them personally in the pre-survey. This, combined with the null effect on WPR grades, seems to indicate that the personal/family oriented problems reach students equally well regardless of their background and predisposition. This was a concern going into the study, and so this fact, combined with the overwhelming positive subjective feedback, was encouraging that incorporating personal/family related problems is a “gimmick” which is only well-received by a small subset of the population.

Not surprisingly, cadet performance on the WPR was not significantly impacted by the experiment. Students in the six sections using personal/family oriented problems had an average score of 157/200, while the other sections had an average score of 161/200. Due to the limited sample size and other confounding factors, it appears that the experiment neither helped nor hurt student comprehension (at least in terms of test preparation).

**Recommendations/Conclusion**

Based on this positive subjective feedback, it is recommended that this topic should be examined further. A larger sample size, and possibly repeating this experiment on other topics in addition to calculus could provide interesting results. A controlled experiment where some students are only given personal/family oriented problems, while others exclusively use textbook problems would also provide better insight into the effectiveness of this approach at helping students better learn material. Any such studies in the future should be careful to ensure that test questions are written in a manner which would not give either subset a distinct advantage.
In conclusion, this study produced mixed results. Although introducing personal/family problems into a calculus classroom did not show any empirical signs of improving student understanding or mastery of the material, it did help students relate to the material and connect with their instructors. Additionally, based on the free text feedback, these type of problems certainly seemed to, at a minimum, provide some degree of diversion or entertainment to students compared with typical problems involving particle motion or the production of “widgets.”

Ultimately, developing the personal/family oriented problems did not require an exorbitant amount of effort. Since these problems were supplemental to the textbook and other problems, they certainly did not hurt student comprehension. Even if these problems did not directly improve student comprehension of the material, students were given a glimpse into the instructors’ lives and families, improving the relationship and personal connection between instructor and student. Based on this, regardless of the lack of a definitive impact on student test grades, this study can be viewed as a resounding success.
Bibliography


