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Investigation of Prioritization and Self-Efficacy in Calculus for Business and Life Science

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Abstract

The self-efficacy of undergraduates in academia is well documented in this century and past. In 1977, Albert Bandura laid the foundation for research and development of self-efficacy theory. Specifically, self-efficacy is defined by Bandura (1977) as the personal assurance that one can "successfully execute the behavior required to produce the outcomes" (p. 193). While undergraduate calculus has been thoroughly studied through the lens of self-efficacy, most research is grounded in calculus courses for mathematics-related majors. While there is a large collection of research on self-efficacy in general calculus courses, there is currently insufficient research directed towards self-efficacy in applied calculus. Additionally, the correlation of self-efficacy and prioritization of undergraduate students has not been sufficiently studied. In the context of undergraduate students, prioritization is what a student decides is more or less important in the context of applied calculus.

To find a comprehensive understanding of the relationship between self-efficacy and prioritization, qualitative and quantitative student feedback is considered in this research. By using student feedback from surveys and writing prompts in a calculus course for business and life science majors, this study can provide a starting point for such research that is currently insufficient. Using a mixed methods approach, students completed surveys before and after the course measuring their self-efficacy and prioritization in terms of the calculus course. Students also completed post-assessment surveys measuring the same three factors through homework, quizzes, and tests. Both quantitative and qualitative data is used to find if there is an existing correlation between self-efficacy and prioritization.

Keywords: *self-efficacy, prioritization, non-math-related major, applied calculus*

Introduction

Context

Calculus is often considered a foundational course, or sequence of courses, for undergraduate students seeking a degree in mathematics (both applied and pure), engineering, and other STEM-related fields. Hackett (1985), in a study on the relationship between gender, mathematics self-efficacy, and choice of college majors, suggests that mathematics self-efficacy is predictive of "math-related major choices" for students. Due to the close relationship between mathematics self-efficacy and mathematics-related majors, there is a considerable quantity of research surrounding the self-efficacy of undergraduates taking calculus (Hackett, 1985; Hackett & Betz 1989). Specifically, this grouping of research involves entry-level calculus courses that "[are] often the first and prerequisite introductory course to most STEM curricula" (Tang et al., 2021, p. 2). In the context of math-related majors, STEM curricula refers to majors such as (but not limited to): mathematics; applied mathematics such as actuarial science, physics, computer science and associated fields of study; and engineering.

Problem Statement

Non-traditional undergraduate calculus, often referred to as "applied calculus," is a form of undergraduate mathematics typically taken by non-math-related majors. In many universities and institutions in the United States, applied calculus is taken by social and life science majors as well as some business-related majors; generally, students that take applied calculus are not in math-related majors. In this study completed at a regional public university in the Upper Midwest, the course learning outcomes in an applied calculus course provide direction for why applied calculus is necessary for non-math-related majors. For both business and life science-related majors, the derivative and integral have applications in their respective fields. For example, business majors utilize differentiation to derive the Annual Percentage Yield formula and estimate costs with marginal analysis. In addition, differentiation can be used in life sciences to model and project population growth. Both applications, in business and life science, are specific examples of application-based course learning outcomes for the applied calculus course in question. In this study, there were a small portion of students in applied calculus that were in math-related major programs: specifically, computer science and manufacturing engineering technology programs.

Existing research in undergraduate calculus regarding self-efficacy is in traditional calculus curriculum courses; consequently, minimal literature exists measuring self-efficacy in undergraduate applied calculus settings. Since mathematics self-efficacy is predictive of "math-related major choices" (Hackett, 1985, p. 2), studying mathematics self-efficacy in traditional calculus students deprives opportunity to engage with non-math-related majors with potentially variant mathematics self-efficacy identities. A rigorous mathematics course such as applied calculus provides the opportunity to investigate the factors and associated effects of self-efficacy for students in non-math-related majors.

Statement of Purpose

Applied calculus, properly titled "Calculus for Business/Life Science," is a form of applied calculus offered at a regional public university in the Upper Midwest with curriculum designed for certain majors related to business and life science. The course covers limits, differentiation, integration, and applications of the derivative; derivatives and integrals with trigonometric functions are not covered. In order to register for the calculus course, students must pass college algebra with a "C" grade or better. Understanding that research for mathematics self-efficacy for students taking calculus exists for students that correlate with high mathematics self-efficacy, the purpose of this study is to measure mathematical self-efficacy in non-math-related majors taking calculus as well as explore their relationship between mathematics self-efficacy and the behaviors related to engaging in applied calculus. This study will attempt to answer the following research questions:

1. To what extent is there a correlation between the self-efficacy and prioritization of the course in question for students in Calculus for Business and Life Science?
2. How did the prioritization and self-efficacy of students in Calculus for Business and Life Science change from the beginning to the end of the semester?

In order to answer the research questions, it is critical to review the literature of self-efficacy and

prioritization with a mathematics education lens and universal denotation. After reviewing the appropriate literature, the justification for investigating the self-efficacy of students taking applied calculus will be clear, so the methodology can be established.

Literature Review

Self-Efficacy

Self-efficacy Theory is involved in many contexts in which the psychology of an individual, or group individuals, is of significance; naturally, self-efficacy holds influence in the field of education. Self-efficacy is the personal assurance that an individual can successfully accomplish a behavior necessary to reach the intended outcome(s) (Bandura, 1977). Albert Bandura first outlined Self-efficacy Theory in 1977; additionally, Bandura (1977) outlined both the influencers of efficacy expectations and the influence of self-efficacy on choice of behavior. According to Bandura (1977), self-efficacy is sourced from and influenced by performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal. While performance accomplishments are past accomplishment (or lack of) by an individual, watching others accomplish tasks is what defines vicarious experiences (Bandura, 1977). These sources contribute to efficacy expectations; the degree of self-efficacy that an individual has. According to Bandura, the extent of perceived self-efficacy will influence the choice of engaging in behaviors and activities (1977).

In mathematics, self-efficacy is a principal factor concerning mathematics performance (Hackett & Betz, 1989). For measurements of attitudes regarding mathematics, self-efficacy uniquely identifies one's confidence to successfully accomplish mathematical tasks or specific problems (Hackett & Betz, 1989). Beyond identifying attitudes towards mathematics, "self-efficacy was the variable most highly correlated with math-related major choice" (Hackett, 1985, p. 51). Because self-efficacy is a key impact on the performance in mathematics and the college major selection of students, self-efficacy in mathematics is "of great interest to researchers" (Hackett & Betz, 1989, p. 261). Using this context, it is clear that studying non-mathematics-related college majors in a calculus setting provides a unique perspective: a calculus course where mathematics self-efficacy is by no guarantee relatively high.

Prioritization

Prioritization, or priority setting theory, is most prominently researched and enacted in the health care field; in that context, prioritization is defined as an "approach to figure out what is more and what is less important in health care" (Nagel & Lauerer, 2015, p. 2). Priority setting theory provides health care administrators with the ability to systematically allocate resources (time and/or funds), often scarce, into a system where administrators see fit (Nagel & Lauerer, 2015): as a result of scarcity, the request for resources will fall short of resources available (Mitton & Donaldson, 2004). The nature of this definition provides adaptability to fields beyond healthcare. In the context of the academic schedule of an undergraduate student, prioritization is to decide what is more and less important, both within the class and among all other student commitments, in regard to completing tasks working towards the desired outcome of the course. A sample of such tasks include, but is not limited to: attending classes, studying for assessments, completing coursework, and attending extra instructional opportunities outside of class (i.e. faculty "office hours"). Prioritization in the context of an undergraduate student is congruent with the context of health care administration in that students will systematically allocate resources (time) to each class and other commitments in a way that reflects how each commitment is prioritized. Research on the method and impact of undergraduate students' prioritization is insufficient; consequently, careful translations from the healthcare field must be used to provide context for understanding prioritization among undergraduate students.

The definition of prioritization framed for undergraduate students has an apparent relationship with self-efficacy. Efficacy expectations for any given behavior influence how humans choose to engage in that behavior (Bandura, 1977); accordingly, the prioritization of a course by an undergraduate student is influenced by self-efficacy. Consider the definition of prioritization: there is an emphasis on the tasks and action taken that reflects the value placed on a course. Action taken towards a mathematics course will certainly include an element of completing math-related tasks; thus, efficacy expectations will impact how a student engages in behavior associated with the prioritization of an undergraduate course.

Methodology

As previously stated, Calculus for Business and Life Science is intended for non-mathematics-related majors. Using a mixed methods approach, this study aims to answer the following:

1. To what extent is there a correlation between the self-efficacy and prioritization of the course in question for students in Calculus for Business and Life Science?
2. How did the prioritization and self-efficacy of students in Calculus for Business and Life Science change from the beginning to the end of the semester?

As a mixed methods design, this study uses the concurrent triangulation design to validate analysis and results of qualitative data. Specifically, the validating quantitative data model is adopted so that qualitative data will support quantitative findings, leading to a merged interpretation of results. Students completed an early course and post-course survey measuring the student's self-efficacy related to calculus as well as prioritization of the applied calculus course; the surveys were quantitative. Test reflections were completed by students after every test to measure prioritization and self-efficacy in calculus in a qualitative manner. The study was completed in a 16-week period between September 2023 and December 2023; completion of all data gathering instruments such as surveys were completed independently outside of class time.

In order to complete data gathering, approval from the university's Institutional Review Board (IRB) was obtained. Approval from the university's IRB was required because the research clearly involves human subjects; thus, the protection of human subjects in the study must be confirmed. The research proposal was reviewed and approved as IRB exempt by the university's IRB on August 28th, 2023. After which, the process of gaining consent from students eligible for participation in the study began. Subjects eligible for the study were students enrolled in the Calculus for Business and Life Science course at the regional public university located in the Upper Midwest. The subjects were to be over the age of 18; all students in the course met this requirement. Subjects received the consent form on the first day of class, along with a short presentation from the instructor communicating that participation was not mandatory and would not impact grades in the class. The consent form communicated the following: the purpose of the study, acknowledgment of no direct benefit from participation, confidentiality of personal information, voluntary participation of the study, and method of keeping data unidentifiable.

Data Collection

Of the 32 students that completed the course, 29 students opted into the study. Information from each participant regarding degree sought was kept unknown; however, the class was intended for specific majors in the fields of business and life sciences. The course is also required for some engineering technology majors, which is a degree in engineering with less intensive "math load."

Data collected from the student participants in the study were Self-Efficacy and Prioritization (SEP) Surveys and Test Autopsies. All instruments were completed as in class assignments, where only the data from students participating in the study was compiled into the research. Both instruments were completed by the student participants, as student participants were the only individuals completing the study. See the following graphic for a catalog of implemented instruments.

Table 1

Data Collection Instruments

Instrument	Data Type	Collection Purpose	Implementation
Self-Efficacy and Prioritization Surveys	Quantitative	Inventory of Likert Scale statements regarding personal self-efficacy of calculus and prioritization of course.	1st implemented in first week. 2nd implemented in final week.
Test Autopsies	Qualitative	Student responses regarding self-efficacy and preparation (prioritization) associated with a given exam.	Following each exam (4).

Self-Efficacy and Prioritization Survey

The Self-Efficacy and Prioritization (SEP) Surveys were implemented twice; once during the first week of the study (and of the course) and once during the university's last week of classes. The SEP survey was

synthesized from five existing Likert scale inventories that measure self-efficacy and prioritization. Likert scale responses were measured on a scale of one to five with five indicating the highest degree of agreement with each statement. Inventory items from Greco's University Academic Self-Efficacy Scale were adopted into the SEP survey. Greco's (2022) University Academic Self-Efficacy Scale follows Bandura's guidelines for constructing self-efficacy Likert scales; the language in Greco's prompts were retrofitted to fit the applied calculus course. Certain inventory items of Nalbone and Zorkina's (2003) Self-Evaluation Questionnaire, which measured participant academic self-confidence with Likert scale statements, were adopted into the SEP Survey. The adaptation of both the University Academic Self-Efficacy Scale and the Self-Evaluation Questionnaire was done with permission because each original instrument was obtained under the terms of the Creative Commons Attribution License (CC BY). Finally, items from the Panorama Student Survey were adopted into the SEP. Items from the Panorama Student Survey categories were used for prioritization measuring items in the SEP Survey. All survey items were adjusted from the early course SEP to the end-of-course SEP to use the appropriate tense.

Of the 45 questioned sourced and retrofitted for the applied calculus course, 23 questions measured student self-efficacy and 22 measured student prioritization. To ensure that participants answered in a consistent manner, survey items were rephrased in different grammatical structures that maintained the same underlying concept. The following self-efficacy item was implemented into the SEP: "I am confident in my ability to obtain the grades I desire in [Calculus for Business and Life Science]." The item was rephrased and implemented in the same SEP: "When it comes to this course, I am not confident in my ability to obtain the grades I desire." With sufficient survey items, self-efficacy and prioritization scores could be generated by averaging each student's respective self-efficacy and prioritization Likert responses. For prompts that invalidated student self-efficacy or prioritization, like the latter example, the student's Likert response was subtracted from six to obtain their true self-efficacy or prioritization score for that item.

After every student's self-efficacy and prioritization scores were calculated for the early course and end-of-course SEP surveys, Pearson Correlation Coefficients were calculated to measure the correlation between self-efficacy and prioritization scores. Each student's self-efficacy and prioritization scores were used as the pairs of data in the Pearson Correlation Coefficient. Two coefficients were calculated: one for the relationship between the two variables in the early course and another for the end-of-year SEP surveys.

In addition to testing the correlation between self-efficacy and prioritization scores, the Mann-Whitney U Test was utilized to test whether or not prioritization and self-efficacy scores significantly changed from the early course SEP survey to the end-of-year SEP survey. For both self-efficacy and prioritization, the two sampled groups are early course scores and end-of-year scores. The Mann-Whitney U Test assesses if the two sampled groups originate from the same population; the one-sided test, with $\alpha = 0.05$, was utilized to determine whether or not a negative shift in self-efficacy and prioritization scores existed.

Test Autopsy

To validate quantitative data, qualitative data was collected in the form of Test Autopsies. Test Autopsies were open-ended question surveys that were implemented after every exam in the course; in total, four Test Autopsies were implemented. Each survey contained 12-16 questions or prompts related to student study habits, preparedness, and confidence for the period after the previous exam leading up to the exam that was administered. Students were given a week following the exam to complete and submit a Test Autopsy. Questions and prompts remained consistent throughout all four implementations of Test Autopsies, with minor rewording and addition/omission of questions carried out.

To analyze the qualitative data collected from the Test Autopsies, thematic analysis will be utilized. Results from the Test Autopsies will be used to supplement findings for both correlation and self-efficacy. Responses from each Test Autopsy item will be separately coded, and themes will be reviewed generated from each item. Then, general themes will be derived holistically from the analysis of every Test Autopsy item. The themes generated from the thematic analysis of each of the test autopsies will be used to supplement, and possibly validate, the quantitative analysis.

Results

The purpose of this study was to answer the following questions using a mixed methods, validating quantitative data model:

1. To what extent is there a correlation between the self-efficacy and prioritization of the course in question for students in Calculus for Business and Life Science?
2. How did the prioritization and self-efficacy of students in Calculus for Business and Life Science change from the beginning to the end of the semester?

Self-Efficacy and Prioritization Survey

Student participation in SEP surveys went from 29 completed surveys in the early course SEP survey to 21 completed end-of-course SEP surveys. The early course SEP survey was the only piece of data collection that every participant fully completed. While more than 29 students completed the early course SEP survey, multiple students dropped the applied calculus course; dropping the course warranted removal of participation in the study.

After every student's self-efficacy and prioritization scores were calculated for the early course and end-of-course SEP surveys, Pearson Correlation Coefficients were calculated in order to measure the corresponding correlation between self-efficacy and prioritization scores. For the early course self-efficacy and prioritization scores, the Pearson Correlation Coefficient was found to be $r = 0.57$. This result implies that there was a weak positive correlation between self-efficacy and prioritization in the early course SEP survey. The end-of-course SEP survey had a similar Pearson Correlation Coefficient; the coefficient was $r = 0.45$. In fact, there was less of a correlation between self-efficacy and prioritization at the end of the course than from the beginning. Both results indicate that there is no significant correlation between self-efficacy and prioritization for students taking the applied calculus course.

With the self-efficacy and prioritization scores, the Mann-Whitney U Test was used to test whether or not prioritization and self-efficacy scores significantly changed from the early course SEP survey to the end-of-year SEP survey. The critical value used to determine the result of the test, for both prioritization and self-efficacy, was 204. If the test statistic $U < 204$, then H_0, that the early course and end-of-course scores did not change, will be rejected. For prioritization, $U = 110$. Thus, the Mann-Whitney U Test finds that prioritization decreases from the beginning to end of the course. For prioritization, $U = 154$. Thus, the Mann-Whitney U Test finds that prioritization decreases from the beginning to end of the course. In short, it was concluded that both self-efficacy and prioritization decreased from the beginning to the end of the course.

Test Autopsies

Thematic analysis of the test autopsies has not been formally completed to this point. These findings will determine whether or not qualitative results support the quantitative findings regarding self-efficacy and prioritization. At a preliminary level, test autopsies support the results from the Mann-Whitney U Test that prioritization decreased from the beginning to the end of the course. After randomly selecting four students from each quartile of the class prioritization scores, their responses from each autopsy were observed for change throughout the duration of the course. Through informal observations, it appeared that all four students lost prioritization in the course by means of less studying, lack of interest, and focus on other commitments. One Fisheries and Wildlife major noted that "I would rather focus on classes like Ichthyology and Limnology that really are more interesting and relevant." This sentiment, that classes that they deemed more closely related to their major were more relevant, was expressed by the majority of students in at least one test autopsy. Another student established their focus on major-relevant courses by stating "lack of motivation to work on [applied calculus] when I have other work in classes I am more interested in." Even simple responses given, such as one student's response that "other classes seemed to take priority" suggest that applied calculus lacks prioritization. Formal thematic analysis will be completed to solidify these findings.

Discussion

From the results in this study, one cannot assume that a certain degree of self-efficacy indicates a degree of prioritization. While a positive correlation was found between prioritization and self-efficacy, the correlation was not statistically strong. For instructors of applied calculus, and potentially other mathematics courses, this

implies that self-efficacy can be developed in spite of a degree of prioritization. Likewise, a student's prioritization of applied calculus can be improved despite any degree of self-efficacy. Instructors may use these findings to improve their mindset and attitude towards teaching students who may not fit their ideal level of self-efficacy or prioritization.

The decrease in self-efficacy and prioritization across the majority of students warrants critical examination of how applied mathematics, in particular calculus, is taught. Applied mathematics is taken by non-mathematics-related majors who value mathematics in a different way than mathematics-related majors do. Thus, applied calculus must engage students in a way that tailors to their academic prowess. Despite applied calculus containing "applied" in its name, many course, including the course in this study, lack curriculum related to the application of calculus in other fields such as business and life sciences. Changing how applied calculus is taught has the potential to change the perspective of non-mathematics-related majors taking the course.

To increase the accuracy of the results of the study, implementation of the study must exist at a larger scale. This study is limited in that less than 30 students participated. Clearly, the results are not irrefutable evidence to support or answer the listed research questions; the results found provide a platform for future research. By implementing this research across multiple regional public universities that offer a similar applied calculus course, a more accurate answer to the research questions will be derived.

References

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioral Change. *Psychological Review*, *84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Greco, A., et al. (2022). Self-efficacy beliefs of university students: Examining factor validity and measurement invariance of the new Academic Self-Efficacy Scale. *Frontiers in Psychology*, 12, Article 498824. https://doi.org/10.3389/fpsyg.2021.498824

Hackett, G. (1985, January). Role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. *Journal of Counseling Psychology*, *32*(1), 47-56. https://doi.org/10.1037/0022-0167.32.1.47

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261–273. https://doi.org/10.2307/749515

Keller, R.E., et al. (2017, November). A structural equation model looking at student's participatory behavior and their success in Calculus I. *International Journal of STEM Education, 4*(24). https://doi.org/10.1186/s40594-017-0093-0

Mitton, C., & Donaldson, C. (2004). Health care priority setting: principles, practice and challenges. *Cost Effectiveness and Resource Allocation, 2*(1), 3. https://doi.org/10.1186/1478-7547-2-3

Nagel, E., & Lauerer, M. (2016). *Prioritization in Medicine* (pp. 1-281). Springer Cham. https://doi.org/10.1007/978-3-319-21112-1

Rowbotham, M., & Schmitz, G. (2013). Development and Validation of a Student Self-efficacy Scale. *Journal of Nursing and Care*, *2*(1), https://www.hilarispublisher.com/open-access/development-and-validation-of-a-student-self-efficacy-scale-2167-1168.1000126.pdf

Tang, D., et al. (2021, December). Self-efficacy and achievement emotions as mediators between learning climate and learning persistence in college calculus: A sequential mediation analysis. *Learning and Individual Differences*, *92*. https://doi.org/10.1016/j.lindif.2021.102094

Zorkina, Y., & Nalbone, D. (2003, January 6). Effect of induced level of confidence on college students' performance on a cognitive test. *Current Research in Social Psychology*, *8*(11), 148-161.