

Warren J. Baker Endowment

for Excellence in Project-Based Learning

Robert D. Koob Endowment *for Student Success*

Proposal Cover Page

Title of Project: Students' self- and peer-questioning strategies in STEM

Proposal Author: Joelle Saute **Cal Poly Email:** jsaute@calpoly.edu

Student ID: 011087345 **Dept:** Mathematics

Signature (Optional): signature provided on hard copy)

Signature provides permission to check financial aid eligibility.

Previous Baker/Koob Endowment funding? (circle one): Yes **No**

Is this request to support a Senior Project or thesis? (circle one): **Yes** No
(partially)

Team Member(s)	Signature	Cal Poly Email	Department
_____	_____	_____	_____
_____	_____	_____	_____

Faculty Advisor: Danielle Champney **Department:** Mathematics

Faculty Advisor email: dchampne@calpoly.edu **Telephone:** 6-5579

Anticipated Start Date: _Winter 2018 **Anticipated End Date:** Winter 2019

Total Funds Requested (\$): 1800

Signature of Faculty Advisor: signature provided on hard copy **Date:** _____

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CAL POLY

PROPOSAL NARRATIVE

(Max. of 3 pages including figures/tables but excluding budget page, 1" margins, 12-point font)

I. Project Title

Students' self- and peer-questioning strategies in STEM

II. Abstract

This study aims to build on an existing line of inquiry in the Research in Undergraduate Mathematics Education community, by extending our understanding of experts' self-questioning strategies in two ways. First, we aim to study students' self-questioning strategies while solving difficult STEM problems, to understand how their own inquiry guides their problem solving in similar and different ways, compared to experts. Second, we aim to study how students' self- and peer-questioning strategies differ – that is, how students' self-inquiry when problem solving is or is not related to their team problem solving strategies. There are a number of different aspects of students' problem solving that could focus this research, but we specifically focus on **questioning** as the means for interacting with students' problem solving strategies so that we can gain a better sense of students' external and internal problem solving dialogues. The work is expected to be of broad enough scope, and submission quality to a peer-reviewed journal, and also acceptable as a Contributed Report at a mathematics education conference.

III. Introduction

Although self inquiry has been studied in various contexts, there is a lack of research focusing on undergraduates dealing with mathematical problem solving. Some of the research that has been done by Cal Poly professors focuses on highly structured, short term inquiry testing of high level mathematics majors as well as professors. What is lacking in this field is longer term research on not only student self-inquiry, but peer inquiry as well. By embedding oneself within a group of students working together over a quarter, the observer is able to record accurate information that is not altered as heavily by stressors such as time restrictions and unfamiliar environments, which were much more present in the other studies conducted. With such an environment available at Cal Poly in MATH 442 and 443, data can be collected to analyze how individual and group inquiry evolves over time, and whether or not it leads to more effective questioning strategies and success in solving problems. With the results of this study, the goal is to expand research on inquiry based learning and provide evidence of the effectiveness of inquiry based learning within and outside of undergraduate level classes.

IV. Research Objective(s)

1. Collect questions asked by the students inside and outside of the classroom regarding the problems they are assigned.

2. Compare the individuals' methods of questioning to successfully complete a problem.
3. Compare the groups' methods of questioning to successfully complete a problem.
4. Compare individual and group methods of questioning from the beginning and end of the quarter.
5. Compare levels of satisfaction with self and group inquiry from the beginning and end of the quarter.
6. Identify the components of a group that result in effective questioning and collaboration.

V. Methodology

After developing and piloting protocols for student interviews, surveys, and observation of team work, we will collect multi-faceted data in MATH 442 and 443 that focus on students' self- and peer-questioning strategies while working on the problem-solving components of these courses. These courses are heavily team-oriented, so it will be necessary to observe in class every day, and embed ourselves in various teams to study their dynamics on an ongoing basis. Additionally, we will collect supplemental data in the form of survey and interview, outside of the class meeting time. This data will provide insight into students self-questioning, which can be compared with observational data on team-based peer-questioning. Video and audio data will supplement the observational data, both from teams in which we are not embedded and as a record of the work of the team(s) in which we are.

MATH 442 and 443 are excellent choices for collecting this type of data because Dr. Champney structures her class around peer and self-inquiry. The goal of class every day is to work through the set of problems she has assigned within a group, avoiding outside resources such as the Internet. If students find themselves faced with a question they cannot answer, Dr. Champney directs them to their peers, rather than answering the question herself. The level of difficulty of the assigned questions varies, allowing for students to build some confidence and skill while working on the easier problems, and then recognize the need to address past questions, ask themselves new questions, and branch out to other students to reach a solution. This environment also provides multiple sources for data collection, since there are typically 5 groups of students. By noting how each group works differently, comparisons can be conducted to evaluate the effectiveness of the strategies being used within the various groups. The prerequisites for this class are also less extensive than those required in the other Cal Poly studies, allowing for analysis of a wider range of academic abilities.

Data analysis will commence after the conclusion of MATH 443, and all sources of data, including survey, observational notes, video data, audio records, and student interviews and focus groups, will be triangulated to compose a profile of self- and peer-questioning for the students enrolled in the course(s). At that juncture, it will be possible to return to existing literature, to make claims about some of the ways that students' questioning strategies are consistent with current literature, and some of the ways that it diverges (and therefore, what that means about students' problem solving). At this point, the study will provide extensions to other STEM disciplines, supporting next steps that prompt further, more interdisciplinary research.

VI. Timeline

Fall 2017: Study Design and Development of Materials

Winter and Spring 2018: Data Collection in MATH 442 and 443

Summer 2018: Begin data analysis and decide if additional data is necessary

Fall 2018: Data Analysis and writing; first quarter of senior project; RUME proposal submitted

Winter 2019: Presentation at RUME Conference; finish writing paper; second quarter of senior project

Spring 2019: Journal article submitted

VII. Final Products and Dissemination

The scope of this project is large, and includes a senior project and independent study work – the goal is to design the study and collect the data in the 2017-2018 academic year so that in the 2018-2019 academic year, we are able to complete an expanded senior project that will be (a) ready for publication in an academic journal such as *Mathematical Thinking and Learning*, and also (b) ready to be presented as a Contributed Report at the 2019 RUME (Research in Undergraduate Mathematics Education) conference. Thus, the final senior project will be both a paper suited for peer-reviewed publication *and* a presentation at a nationally recognized Math Education Conference.

VIII. Budget Justification

Sound qualitative research relies on video and audio data collection, and lots of time spent with student observation, and in group and individual interviews, with specific protocols for studying their problem solving and asking questions about their experiences. To do this well, video and audio equipment is necessary. Unfortunately, it is difficult to obtain for extended periods of time (i.e. 2 quarters) on a rental basis, and money for this is not often included in Operating Expenses for departments such as Mathematics, where there is relatively little need for equipment. Thus, the equipment cost here includes money for enough video cameras to capture all groups' work (5 @ ~\$80 each), as well as audio recorders to have an audio backup (5 @ ~\$40 each) and hard drives for data storage (2 @ ~\$50 each). The audio and video recorders would also be used extensively for student interviews. The funding for software is for a license for Geometer Sketchpad software that the class uses, so that we will have access to the same materials (~\$100 from McGraw Hill). Finally, the Conference Travel is for the RUME (Research in Undergraduate Math Education) conference (2019) so that the results of the study may be presented as a Contributed Report. Average registration fee for this conference is over \$450, before airfare, hotel, and meal expenses (we expect some partial aid from Champney, which cannot cover the full cost of travel to the conference, which typically runs 3-4 days).

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PROPOSAL BUDGET

Student Applicant(s): Joelle Saute	
Faculty Advisor: Danielle Champney	
Project Title: Students' self- and peer-questioning strategies in STEM	Requested Endowment Funding
Travel <i>subtotal</i>	\$1000
Travel: In-state	\$
Travel: Out-of-state	\$1000
Travel: International	\$
Operating Expenses <i>subtotal</i>	\$ 800
Non-computer Supplies & Materials	\$700
Computer Supplies & Materials	\$
Software/Software Licenses	\$100
Printing/Duplication	\$
Postage/Shipping	\$
Registration	\$
Membership Dues & Subscriptions	\$
Multimedia Services	\$
Advertising	\$
Journal Publication Costs	\$
Contractual Services <i>subtotal</i>	\$
Contracted Services	\$
Equipment Rental/Lease Agreements	\$
Service/Maintenance Agreements	\$
TOTAL	\$1800

Danielle Champney
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November 3, 2017

To the Baker-Koob Endowment for Student Success Selection Committee:

I am writing in support of my student, Joelle Saute, who is submitting a proposal to support her undergraduate mathematics education research. This research will encompass a senior project, but will extend to be much more – we anticipate that the ambitious scope of the research will produce a journal article for a peer-reviewed journal (such as *Mathematical Thinking and Learning*), as well as a presentation at a nationally recognized conference for Mathematics Education (RUME).

Joelle's research was inspired by previous work by two of my colleagues in the mathematics department, and their ongoing work related to experts' problem solving in STEM, which they have presented at previous RUME conferences. Joelle will extend this work carefully, in multiple ways, to build upon the existing findings, and produce further study that will offer interesting comparisons and additions to the existing body of literature. She is in a unique position to do this because, as a 3rd year student, she is able to spend some significant time on designing a careful study and collecting meaningful data *before* the official scope of her senior project begins, so that when she enrolls in MATH 461 and 462, she can dedicate her time to the serious undertaking of careful journal-ready writing.

Research in math education requires equipment that is often hard to come by in a department such as mathematics. Our OE budget is often slim, as no specialized equipment, except for books and software, is often needed. However, to do careful qualitative data collection and analysis, we require the reliable use of video and audio equipment, for an extended time. This includes video cameras for capturing student team work – to capture both their discussion but also body positioning, gaze, interaction with environment, etc... – as well as audio equipment for audio backup of their conversations and hard drives for storing video and audio data.

I would be thrilled to travel with Joelle to the RUME conference in Winter 2019 to present her work, after completing this study. The conference in 2019 is in Oklahoma, and I anticipate that I will have some partial supplemental funds take her with me to the conference – however, this conference has extremely high registration costs, so her budget will include some partial travel support to co-fund her trip to present her work at RUME in 2019.

I hope you will consider committing to Joelle to support her project – I have worked with students during the last 4 summers on undergraduate research, support them via independent study during the academic year, and often travel with students to present our joint work, and I think Joelle will truly excel, and produce excellent work, if given the time and resources that will support her. Thank you in advance for your consideration of Joelle – an exceptional student.

Danielle Champney