Exploring Learning Difficulties in Multivariable Calculus

Catherine Matta, Gabriel Feinberg, and Fabiana Cardetti
Mathematics Education REU Project
University of Connecticut
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BACKGROUND

This pilot study used student perceptions about their understanding of mathematics to guide the development of learning aids for multivariable calculus classes. Studies on the use of computer technology in advanced mathematics classrooms have shown that technology can help with the understanding of abstract concepts (Godaszi, Elahe Aminifar, & Bakhshalizadeh, 2009; Verner, Aroshas, & Berman, 2008). In addition, other researchers have found that using real-world applications and Inquiry Based Learning (IBL) projects can also help students not only with their learning but also with their enjoyment of mathematics (Hassi & Laursen, 2009; Spronken-Smith, Walker, Batchelor, O'Steen, & Angelo, 2012; Stillman, Galbraith, Brown, Edwards, 2007). In this study, these approaches were used in conjunction with students' perceptions (Pierce, Stacey, & Barkatsas, 2007; Schoenfeld, 1989; Szydlik, 2000) to develop learning aids for multivariable calculus.

Research Questions:

1. What are the general learning preferences and difficulties students face with multivariable calculus?
2. What potential or usefulness do students see in the learning aids designed to assist understanding of certain multivariable calculus topics?

METHODS

Participants

•Twelve students participating in REU programs at the University of Connecticut (Mathematics and Chemistry students)

•All participants, excluding three, had reported having already taken a course in multivariable calculus.

Study Design

Phase 1: The participants completed a survey, Survey 1, which focused on identifying their overall learning preferences and challenges with multivariable calculus.

Phase 2: This phase consisted of the development of learning aids based primarily upon the data from Survey 1

Phase3: Participants completed a second survey, Survey 2, after a short presentation of the learning aids in order to evaluate their potential usefulness in the classroom.

Data Collection

Survey 1: 20 Likert-scale items, 15 multiple-choice items, and 3 open-ended questions.

Survey 2: 12 open-ended questions.

Data Analyses

• Quantitative data was analyzed using SPSS

• Open-ended responses (qualitative data) were analyzed to further understand the quantitative responses, to find recurrent themes, and to garner useful feedback on the learning aids.

RESULTS I & DISCUSSION

Table 1: Selected Attitude Questions (scale range 1 – 5)

	Question	Mean	St. Dev.
5.	I learn better when I can visualize what is being taught.	4.33	0.6236
14.	I learn better when someone else shows me how to do a problem rather than when I do it myself.	2.17	0.6872
17.	I learn better when I see how formulas are derived or how theorems are proven.	4.17	0.986
20.	I would like to understand the real-world applications of mathematics concepts.	4.00	0.8165

These questions in particular helped guide the specific type or format of learning aids. For example, Question 20 informed our decision to include a real-world application as one of the learning aids.

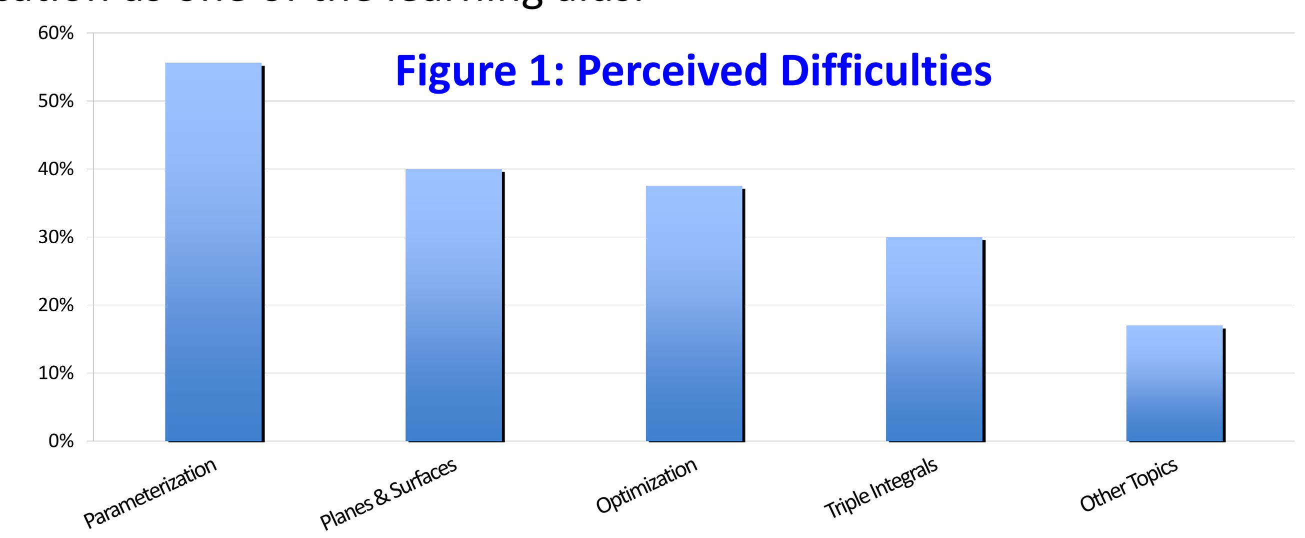


Figure 1: Perceived Difficulties

The above figure represents the distribution of students' perceived difficult topics. Four outstanding topics were chosen to create the learning aids (shown below).

LEARNING AIDS

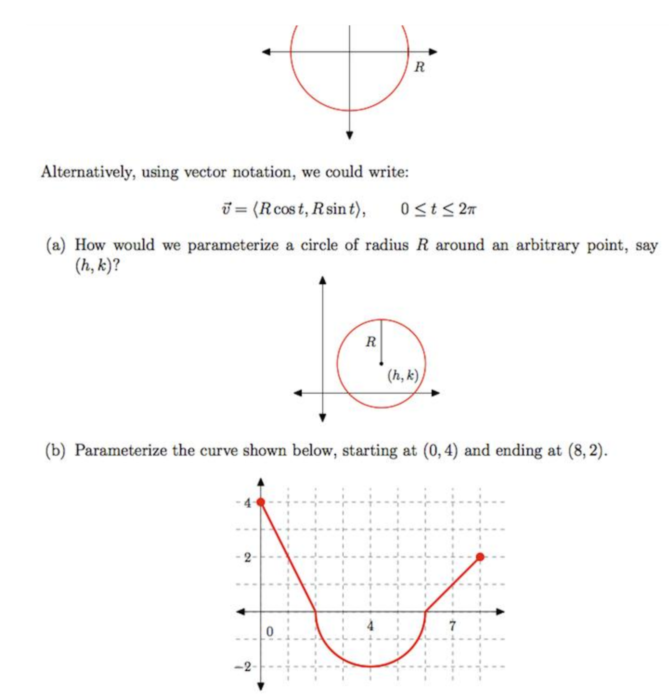


Figure 2: Parameterization Project

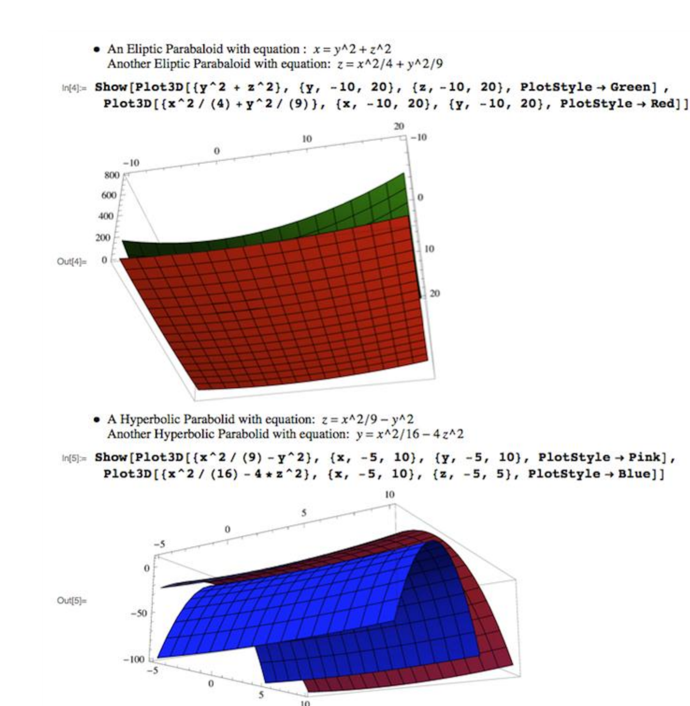


Figure 3: Planes and Surfaces Visual Aid

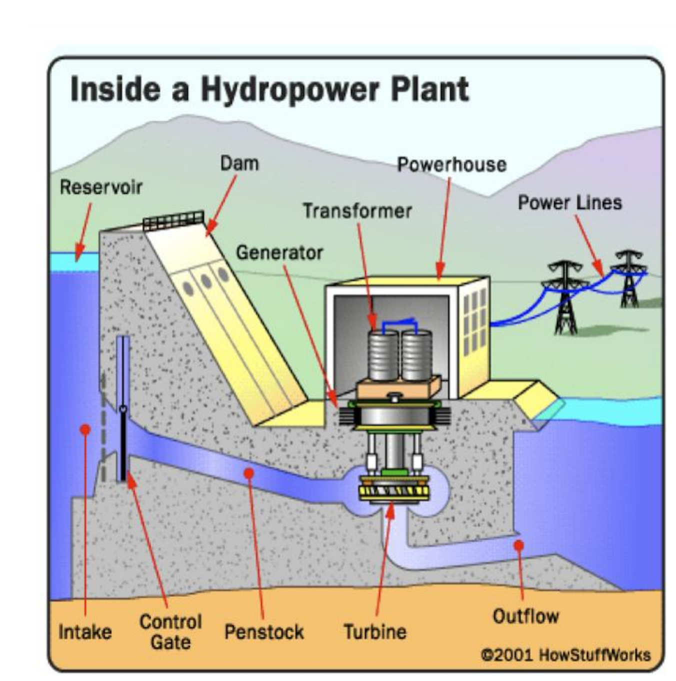


Figure 4: Optimization Application

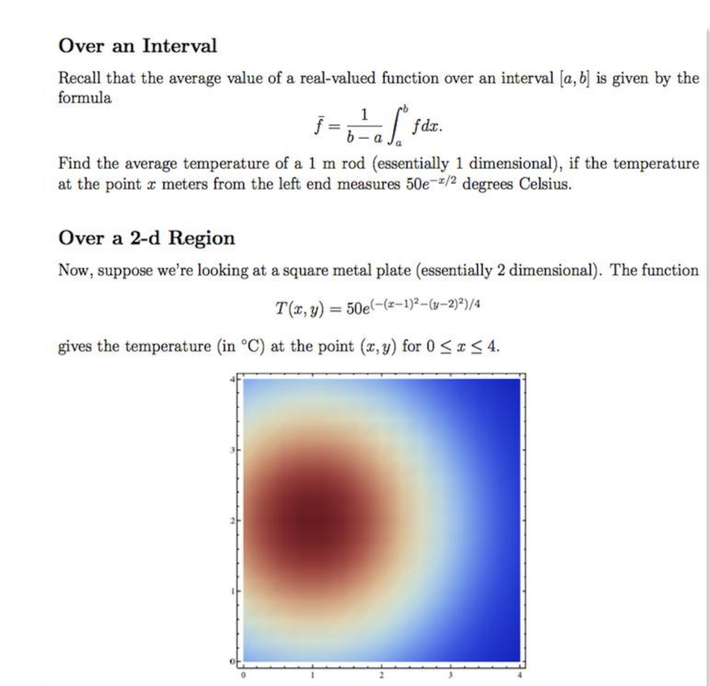


Figure 5: Triple Integral IBL Project

RESULTS II & DISCUSSION

The figures below show the participants' feedback for each of the four learning aids. In general, participants found them useful tools for multivariable calculus.

Figure 6: Parameterization Project

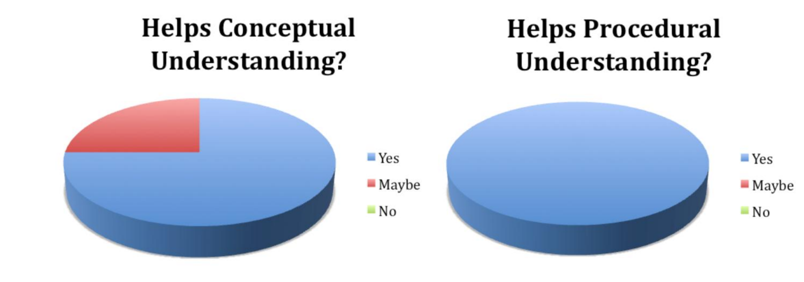


Figure 7: Planes and Surfaces Visual Aid

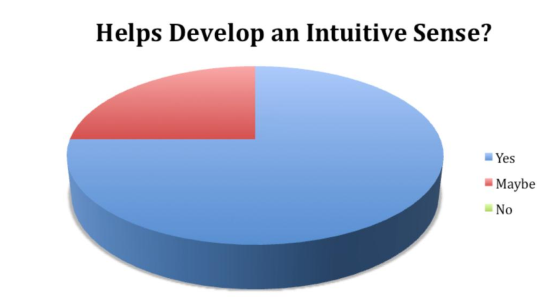


Figure 8: Optimization Application

Feedback on the usefulness and structure of the project were split. Selected thoughts below:

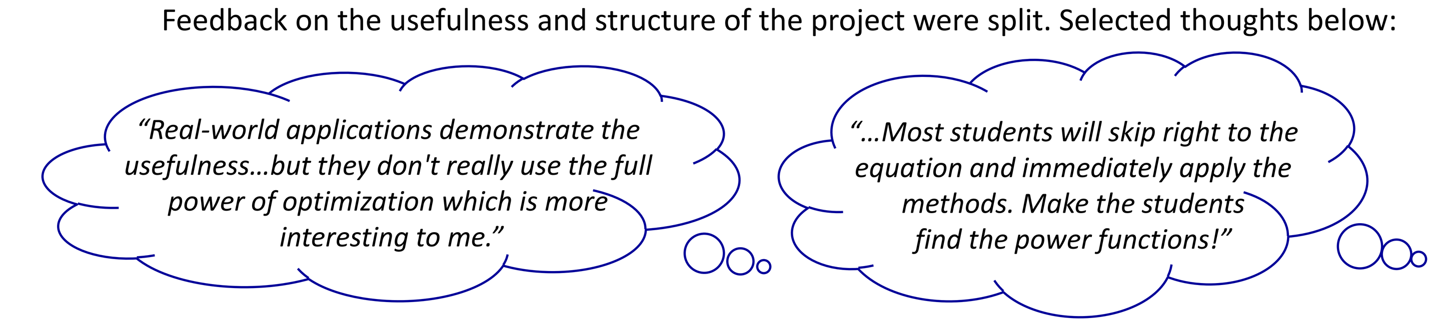
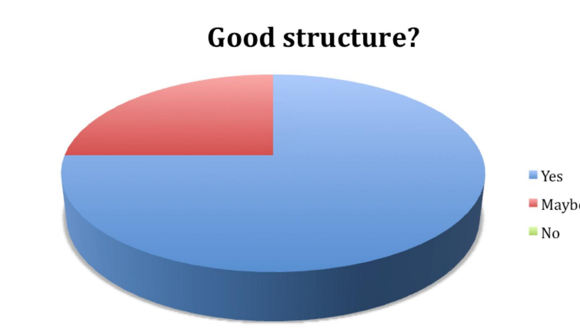


Figure 9: Triple Integral IBL Project



CONCLUDING REMARKS

This study helped us gain insight about students' preferences and difficulties with multivariable calculus. These findings allowed us to create relevant learning aids. The participants generally reported their belief that these aids would be useful. Further research is necessary to determine the effectiveness of these learning aids in a multivariable calculus classroom.

REFERENCES

Hassi ML, Laursen S (2009), Studying undergraduate mathematics: exploring students' beliefs, experiences and gains. *Proceedings of the Thirty First Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. 5, 113-121.

Godarzi, S. Q., Aminifar, E., & Bakhshalizadeh, S. (2009). The impact of using computer algebra systems (CAS) in teaching and learning of "double integral". Unpublished Manuscript.

Pierce, R., Stacey, K., & Barkatsas, A. (2007). A scale for monitoring students' attitudes to learning mathematics with technology. *Computers and Education*, 48(2), 285-300.

Schoenfeld, A. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education,* 20(4), 338-355.

Spronken-Smith, R., Walker, R., Batchelor, J., O'Steen, B., & Angelo, T. (2012). Evaluating student perceptions of learning processes and intended learning outcomes under inquiry approaches, *Assessment & Evaluation in Higher Education*, 37(1), 57-72.

Stillman, G., Galbraith, P., Brown, J., & Edwards, I. (2007). A framework for success in implementing mathematical modelling in the secondary classroom. *Mathematics: Essential Research, Essential Practice*, 2, 688-697.

Szydlik, J. E. (2000). Mathematical beliefs and conceptual understanding of the limit of a function. *Journal for Research in Mathematics Education,* 31(3), 258-276.

Verner, I. M., Aroshas, S., & Berman, A. (2008). Integrating supplementary application-based tutorials in the multivariable calculus course. *International Journal of Mathematical Education in Science and Technology,* 39(4), 427-442.

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