Exploring Learning Difficulties in Multivariable Calculus

Catherine Matta, Gabriel Feinberg, and Fabiana Cardetti
Mathematics Education REU Project
University of Connecticut
Summer 2012

BACKGROUND
This pilot study used student perceptions about their understanding of multivariable calculus 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
Phase 3: 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)
<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. I learn better when I can visualize what is being taught.</td>
<td>4.13</td>
<td>0.6236</td>
</tr>
<tr>
<td>14. I learn better when someone else shows me how to do a problem rather than when I do it myself.</td>
<td>2.17</td>
<td>0.6872</td>
</tr>
<tr>
<td>17. I learn better when I see how formulas are derived or how theorems are proven.</td>
<td>4.17</td>
<td>0.986</td>
</tr>
<tr>
<td>20. I would like to understand the real-world applications of mathematics concepts.</td>
<td>4.00</td>
<td>0.8165</td>
</tr>
</tbody>
</table>

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.

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

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.

REFERENCES

A special thanks to all our participants!