Assessment

Participants

At the beginning of the semester, Dr. Munakata and Mr. McManus recruited participants for the study. The choice to participate was entirely voluntary and without compensation. Participants knew that Dr. Vanderklein would teach a mathematics lesson in two of their labs, but they were unaware of what mode of instruction they would receive. Confidently of student data was maintained in data files, reporting to the public, and reporting to Dr. Vanderklein.

Of the 47 participants, 88% described their major as biology or biology with a concentration in another discipline; 19% described their major related to another field, such as geography, environmental science, and sociology. In terms of mathematical experience, 56% of the participants had to take the lowest credit-bearing mathematics course (MATH100) when they began their studies; this experience was evenly dispersed through the groups; gender was not evenly dispersed across the groups (Table 1).

Table 1: Gender demographics and total participants in groups.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Partial Treatment</td>
<td>9</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Full Treatment</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

Analysis

Analysis of the effectiveness of the modules was based on a quantitative and qualitative approach. The quantitative approach consisted of two analyses. For this part of the analysis the following hypothesis was tested:

H0: Full treatment group will achieve an overall higher grade for the course than the partial treatment group which will achieve an overall higher grade than the control group.

The second quantitative approach looked at how well students did in the course in general based on their level of math background. This was based on how much math and which math courses students reported to have taken prior to taking BIO123.

A qualitative assessment was also done to look at student attitude towards math and its integration into an ecology course. The analysis was based on answers students gave in focus group discussions. These discussions were held for each treatment group separately.

Table 2: Summary of student performance in response to treatments and other factors.

<table>
<thead>
<tr>
<th>Influencing Factors</th>
<th>Exam Scores</th>
<th>Final Lab Score</th>
<th>Final Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Partial Treatment</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Full Treatment</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Gender (male)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MATH100</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Quantitative

Quantitative analyses of student performance on exams in the lab showed that the full treatment group did better in general than the control or partial treatment groups (Table 2). Interestingly, we also discovered that students who were required to take MATH100 (a math-ramp-up course) fared more poorly regardless of treatment. Not surprisingly, students who had taken more quantitative courses (not defined) did better regardless of treatment. Most surprising was the result that male students did less well than female students on the whole. There was no impact of the treatments on well the students did on the exam specific questions (Table 2).

Qualitative

At the end of the semester discussions were held with focus groups from each treatment group. Student responses were generally positive, but indicated that the idea of integrating math into ecology was a foreign idea. The following comments illustrate the general responses from the students across the treatment groups.

Control Group
- Math and math courses are not "conceptual."
- Knowing math is knowing how to find data in word-problems.
- Math has concrete and definite solutions.
- They referred to BIO123 math as "basic math," yet they felt lost in it.
- At the end of the course, they saw value to math for communication of ideas.
- They suggested that math content needs to be addressed in shorter time segments.
- Students claimed that math is something new to biology [education].

Partial Treatment Group
- Math and science are interconnected: math is the language of science.
- Math is necessary for the replication of scientific studies.
- Though they took statistics courses, they admitted not knowing how they would use this again.
- This course was "math intensive" with respect to other classes; yet not as much as high school.
- The math was more than course filler.
- Math gives "a broader perspective" of science; it allows us to see impact and effect.
- Students wanted more examples and sequencing that builds from basic concepts.
- Students wanted more experiences with statistics and graphing.
- Addressed that they have forgotten math because they have not done it in a long time.

Conclusions

Overall, students felt that math was important for understanding ecological principles, but there was a clear indication that students did not see how math was supposed to be integrated and did not feel capable to do this. Students also prepared them for understanding biology. Additionally, they felt that earlier biology course could have given them more preparation for the math they were expected to use in their later courses such as ecology. This was also supported by the fact that the more quantitative courses students had taken the better they did. Thus, an argument could be made to include more math specific exercises into the introductory biology courses. As well, a broader conversation could be held with the math course instructors regarding the problems that they cover. However, it is also important to point out that our results also suggest that the method of math instruction needs to be more hands-on and less prescriptive in order to be more effective. Our hypotheses that more hands-on teaching would result in better performance on math related questions were partially supported. There was no measurable impact on how students fared on the specific math-based questions on the exams (Table 2); however, the full treatment students did better than the others (Table 2).

Further analysis of the data indicated some trends that were not fully expected. It was no surprise that students who needed to take an additional ramp-up math course did less well in the class than those who were not required to take the additional math course. Consistent with this was the finding that those students who had taken more quantitative courses did better as well. The surprising and disturbing result was that male students did less well in the course than female students. This is consistent with Oswald et al. (2004) that found that male students performed less well in a number of categories compared to female students. The question remains, how to address this issue.

Bibliography


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Crossing Boundaries in Undergraduate Biology Education

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