Impact of Research Courses in the Learning Process of UPRM Geology Students

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The Geology Department will develop in each student, critical thinking, enthusiasm, initiative and the necessary skills to become lifelong students of Earth Sciences. Emphasis will be placed on learning basic concepts and techniques through research, in an environment that promotes the development of professionals with social, cultural and humanistic sensibility as well as profound ethical values.
Main Objective of this Assessment

To learn more about the impact of our undergraduate research courses (Geol 4049 and Geol 4055) in the learning experience of our students and provide recommendations for future changes of our curriculum.
Assessment Strategy

- A questionnaire was prepared
- Data were collected during 5 semesters, from Fall 04 to Fall 06
- 76 questionnaires were collected
- An Intervention was done for the scientific method:
  - Pre-Test
  - Workshop
  - Post-Test
- Conclusions and Recommendations were given
Number of Students Registered in Undergraduate Research

![Bar chart showing the number of students registered in undergraduate research projects over different semesters. The chart includes data for Geol 4049 and Geol 4055, as well as a total count.](chart.png)
Assessment of Several Aspects

<table>
<thead>
<tr>
<th>Weighted Average Answer</th>
<th>Geol 4049</th>
<th>Geol 4055</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Defined Project</td>
<td>4.25</td>
<td>4.28</td>
<td>4.58</td>
</tr>
<tr>
<td>Faculty was Helpful</td>
<td>4.33</td>
<td>4.36</td>
<td>4.36</td>
</tr>
<tr>
<td>Learned Scientific Method</td>
<td>4.25</td>
<td>4.32</td>
<td>4.28</td>
</tr>
<tr>
<td>Applied Knowledge from Courses</td>
<td>4.53</td>
<td>4.52</td>
<td>4.52</td>
</tr>
<tr>
<td>Exposed to New Concepts</td>
<td>4.53</td>
<td>4.56</td>
<td>4.56</td>
</tr>
<tr>
<td>Developed Analytical skills</td>
<td>4.53</td>
<td>4.56</td>
<td>4.56</td>
</tr>
<tr>
<td>Challenging Experience</td>
<td>4.56</td>
<td>4.56</td>
<td>4.56</td>
</tr>
<tr>
<td>Improved Writing Skills</td>
<td>4.32</td>
<td>4.32</td>
<td>4.32</td>
</tr>
<tr>
<td>Improved Oral Skills</td>
<td>4.45</td>
<td>4.44</td>
<td>4.44</td>
</tr>
<tr>
<td>Gained Confidence in Research</td>
<td>4.45</td>
<td>4.44</td>
<td>4.44</td>
</tr>
</tbody>
</table>
Intervention: Workshop of the Scientific Method

Pre-Test

Give Presentation

Compare Both Tests

Post-Test

Give 2nd Test

Same abstract than in the pre-test

Group Discussion

An example

El Método Científico

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Structure of the Tests to Assess the Knowledge of the Students in the Scientific Method

Part 1: Introduction Questions

Students were asked to provide the following information:

Department:
Study Year:
Do you know the scientific method?

Part 2: Steps of the Scientific Method

Students were asked to identify the following steps in a research abstract:

A. Observation
B. Scientific Question
C. Hypothesis
D. Experimentation
E. Conclusions

EXAMPLE OF THE ABSTRACT USED:

Understanding life on earth: molecular comparison of cyanobacteria present in the green layer of two tropical hypersaline microbial mats at the Cabo Rojo Salterns in PR

Microbial mats are stratified microbial communities developed in a variety of environments such as hypersaline lagoons, deserts and alkaline lakes. These microbial communities are vertically distributed according to environmental factors like light intensity and redox gradients. It is important to study these microbial ecosystems, because they represent life under Earth’s early conditions. That is why recent astrobiological research is relating microbial mats with a way to explore and determine the possibility of life in other planets. Cyanobacteria are responsible for the phenomenon known as trapping and binding of sediments, which is essential in the mineralization and architecture of microbial mats. The main focus of this research is to identify and compare the prokaryotic oxygenic phototrophs present in two types of microbial mats in the Cabo Rojo Salterns of Puerto Rico, one being more developed than the other, and both from different locations. The green layer of the mats was separated, and total DNA extracted. Amplicons were obtained by means of the Polymerase Chain Reaction (PCR) using Cyanobacterial specific primers. These amplicons were cloned and transformed onto a bacterial host, obtaining a total of 120 clones by each mat. A total of 24 clones were analyzed molecularly by Restriction Fragment Length Polymorphism (RFLP). The data suggest differences in the diversity and complexity of Cyanobacteria in both sites. Five clones of each mat were sequenced, and analysis in silico confirmed the RFLP patterns. In future studies, Cyanobacterial composition of each of these mats will be evaluated under different environmental conditions.
Do you know the Scientific Method?

- Geol 4049: 86% Yes, 14% No
- Geol 4055: 75% Yes, 25% No
- No Research: 91% Yes, 9% No
Correct Answers during the Pre-Test
Correct Answers during the Post-Test

Steps of Scientific Method

<table>
<thead>
<tr>
<th>Observation</th>
<th>Scientific Question</th>
<th>Hypothesis</th>
<th>Experimentation</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>14</td>
<td>0</td>
<td>57</td>
<td>100</td>
</tr>
<tr>
<td>67</td>
<td>45</td>
<td>36</td>
<td>64</td>
<td>67</td>
</tr>
<tr>
<td>71</td>
<td>67</td>
<td>91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Correct Answers from Students with Research Courses

Steps of Scientific Method

- Observation
- Scientific Question
- Hypothesis
- Experimentation
- Conclusions

Per Cent (%) of Correct Answers

<table>
<thead>
<tr>
<th>Steps of Scientific Method</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>Scientific Question</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Experimentation</td>
<td>46</td>
<td>79</td>
</tr>
<tr>
<td>Conclusions</td>
<td>14</td>
<td>69</td>
</tr>
</tbody>
</table>
Correct Answers from Students without Research Courses

Steps of Scientific Method

- Observation: Pre-Test 18, Post-Test 9
- Scientific Question: Pre-Test 27, Post-Test 45
- Hypothesis: Pre-Test 27, Post-Test 36
- Experimentation: Pre-Test 27, Post-Test 64
- Conclusions: Pre-Test 27, Post-Test 91
Conclusions-Students

- The number of students registered in undergraduate research courses (Geol 4049 and Geol 4055) has been increasing in recent years.

- This current trend demonstrates that actual structure and requirements of the research courses could be a problem for the faculty and the quality of education offered in these courses. Therefore, the learning process could be affected.
Conclusions-Courses

According to the students, the strongest aspects of their research experience are:

- Exposed to new concepts
- Develop analytical skills
- It is challenging

But, they also think that the following aspects need to be improved:

- Better Defined Projects
- Learn the Scientific Method
- Improve the Writing Skills
Conclusions-Courses

- Major differences were found between students registered in the first semester (Geol 4049) and in the second semester (Geol 4055) in the following aspects only:
  - Well Define Project
  - Applied Knowledge from Courses
  - Gained Confidence in Research

- According to them, the first semester had more impact in those aspects than the second semester.

- The differences of the other evaluated aspects, however, were low between the two groups.

- This assessment suggests that only one semester of research could be enough to impact the learning process of our students.
Conclusions-Scientific Method

- The students think that they know the scientific method, but the workshop showed that they do not.

- At the beginning of the workshop most students had problems to identify all five steps of the scientific method.

- No clear trend was shown between students with and without research courses, although this last group showed a small improvement.
Conclusions-Scientific Method

- The workshop of the scientific method was effective on improving the capabilities of the students to identify the:
  - Scientific Question
  - Experimentation
  - Conclusions

- However, it confused them to identify:
  - Observation and Hypothesis
Recommendations

- The structure of the undergraduate research courses must be reviewed in order to improve those aspects that are weak.

- Evaluate the possibility of changing the curriculum to require only one semester of research and leave the second semester optional.

- A better workshop of the scientific method should be designed and offered to all students registered in the first research course (Geol 4049).
Next Assessment Project

- Many Geology students have problems with mathematics.
- These problems could be responsible for bad performance in Geology courses and a delay in the graduation date.
- Therefore, it is necessary to assess this problem, evaluate the above hypothesis, and provide recommendations.
- Our next project will include the assessment of the experience of our students in mathematics.
ACKNOWLEDGMENTS

- Students that participated in this assessment
- Faculty of the Geology Department
- Johannes Schellekens (Department’s Director)
- Wilson Ramirez and James Joyce (members of the assessment committee)
- “Oficina de Avalúo para el Aprendizaje y Mejoramiento Continuo” of the Faculty of Arts and Sciences