



ASSESSMENT OF STUDENT LEARNING **Department of Geology** **University of Puerto Rico at Mayaguez**



Progress Report for August to December of 2006

SECTION I: Mission and Student Learning Outcomes

The Geology Department of the University of Puerto Rico at Mayaguez seeks to provide the highest levels of education through continuous revision and expansion of our educational, research, and outreach programs in order to produce well-trained, competent, academic and professional geoscientists capable of responding to societal needs.

We 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.

SECTION II: Department Student Learning Assessment Project

Focus of Assessment Project

During this semester we continued assessing student learning in the Geology Department by the revision of the curriculum. The collected data are used to evaluate the performance of the Department, which will provide recommendations to accomplish our Mission and Objectives. Specifically, this assessment project was focused on the impact of research courses on the learning process of the Geology students. This is part of the overall process that we have started to evaluate how the curriculum is matching with the Geology student profile.

Justification

Every undergraduate student in the Department of Geology has to take two undergraduate research courses (Geol 4049 and Geol 4055). This experience must provide to the students the opportunity for applying their theoretical knowledge into research and to more practical applications to society. According to our profile, the Geology students must have research skills and the capabilities to apply their knowledge to the benefit of society. Therefore, the assessment activities presented here were focused on determining the impact of the research experience over our students learning. It also helps us to provide recommendations for future changes of our curriculum.

Population

In the first stage of this assessment project a questionnaire was submitted to all students enrolled in the courses Geol 4049 (Undergraduate Research I) and Geol 4055 (Undergraduate Research II) during five semesters between fall 2004 and fall 2006. The used questionnaire is included in the appendix. A total of 76 questionnaires were collected and used for the analyses presented here. The numbers of students registered in undergraduate research and that participated this study are presented in Figure 1. In the second stage of the project a workshop of the scientific method was given to the students registered in these courses during fall 2006 and to students that have not taken these courses. Moreover, it was possible to compare three different populations of students with different levels of research experience.

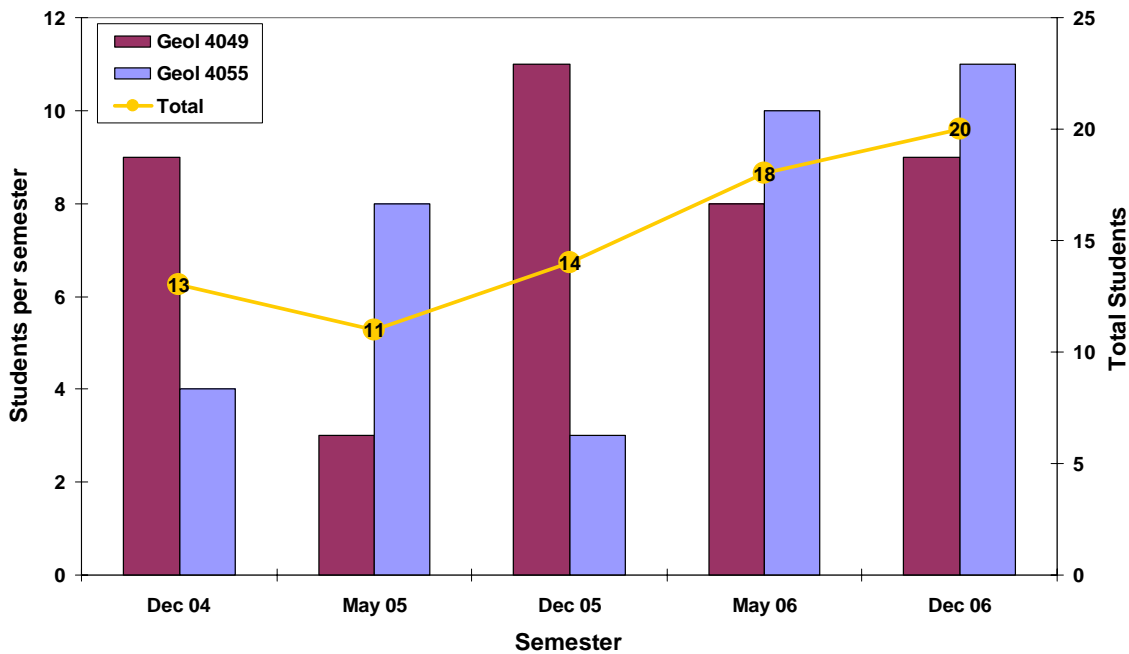


Figure 1: Number of students registered in undergraduate research courses.

Pre-Intervention

During the past two years we have been collecting data using the questionnaire included in the appendix. Ten different aspects of the research experience were evaluated in a scale of 1 to 5, where 1 mean that they strongly disagree and 5 mean that they strongly agree. All data from the 76 questionnaires were averaged and weighted in order to report only one representative number for each evaluated aspect. These data were analyzed in order to determine the impact of the research courses over the students' knowledge and skills. Figure 2 shows the results.

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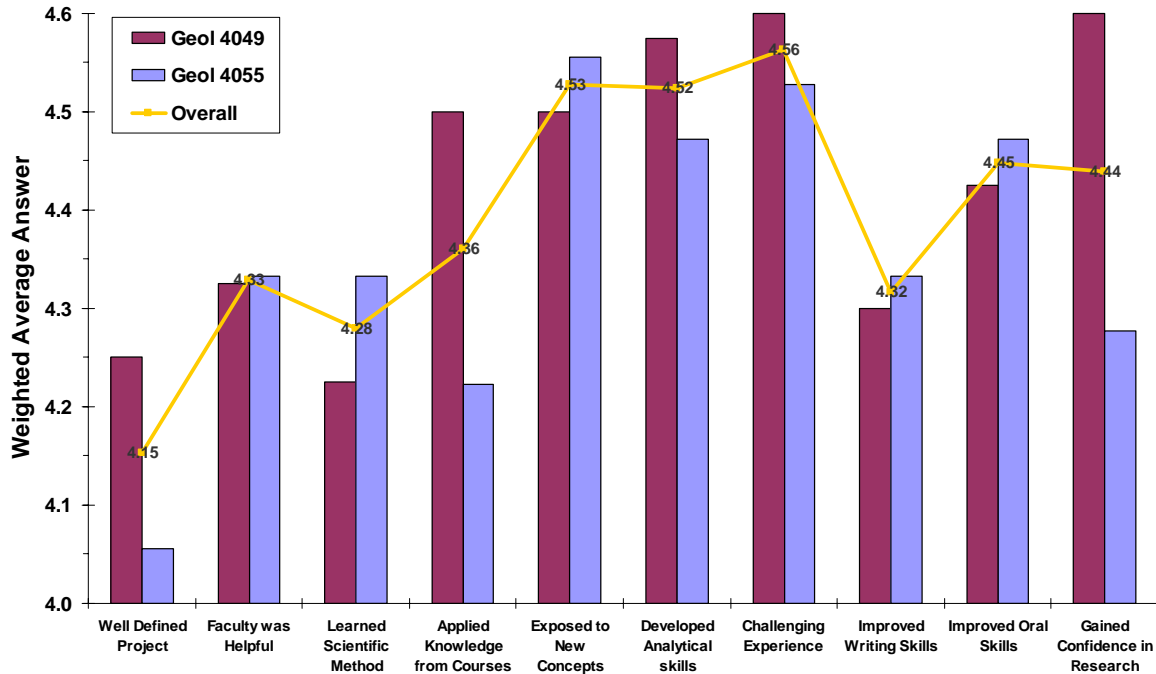


Figure 2: Assessment of several aspects of the research experience during the courses.

Intervention

Based on the findings of Figure 2 we selected the scientific method for our intervention. A workshop was prepared to evaluate and improve the actual knowledge of the Geology students in that aspect. A pre-test was given where they had to identify in an abstract the 5 steps of the scientific method: observation, scientific question, hypothesis, experimentation, and conclusions. They also had to answer if they knew the scientific method (Figure 3). That helped us to know the impression of the students about their knowledge of the scientific method.

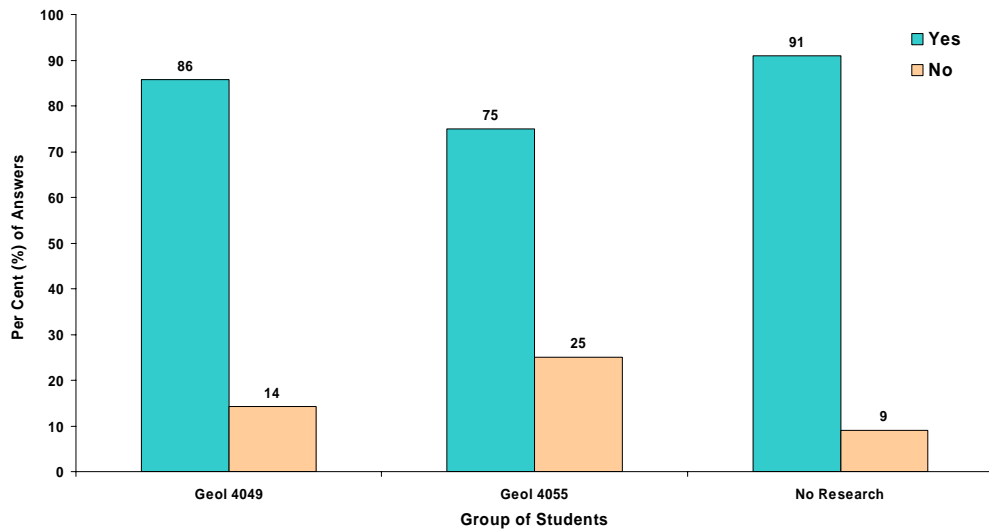


Figure 3: Answers to the question: Do you know the scientific method?

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An oral presentation of the scientific method was given after the pre-test. Finally a similar abstract to the pre-test was discussed. Both the pre-test and the presentation are in the appendix.

Post-Intervention

The effectiveness of the workshop was determined using a post-test. It consisted of the same abstract used for the pre-test. That helped us to evaluate if the students improved their capabilities of the scientific method after receiving the workshop. The correct answers for the three groups of students that were evaluated (Geol 4049, Geol 4055, and students without a research course) are presented in Figure 4 for the pre-test and Figure 5 for the post-test.

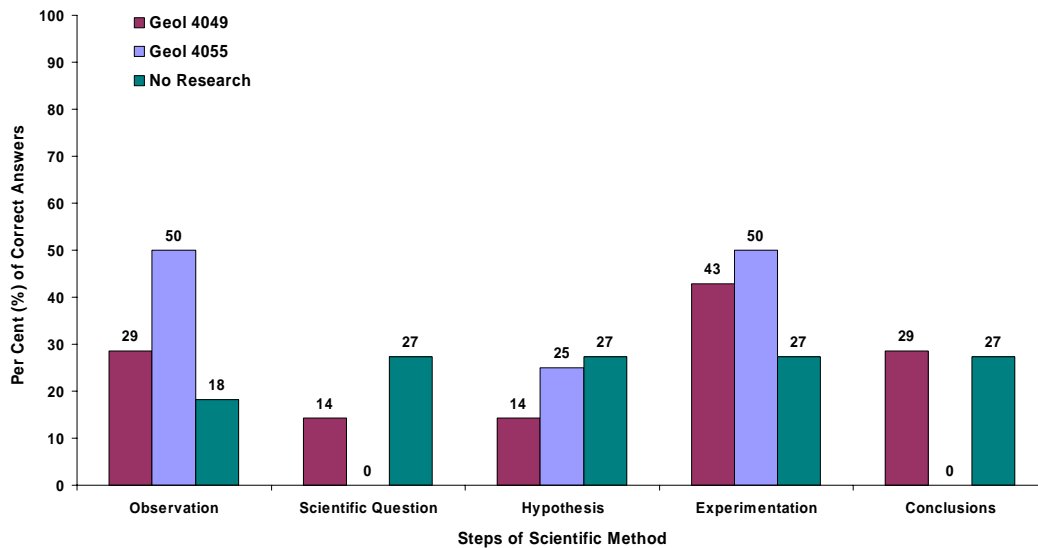


Figure 4: Correct answers during the pre-test.

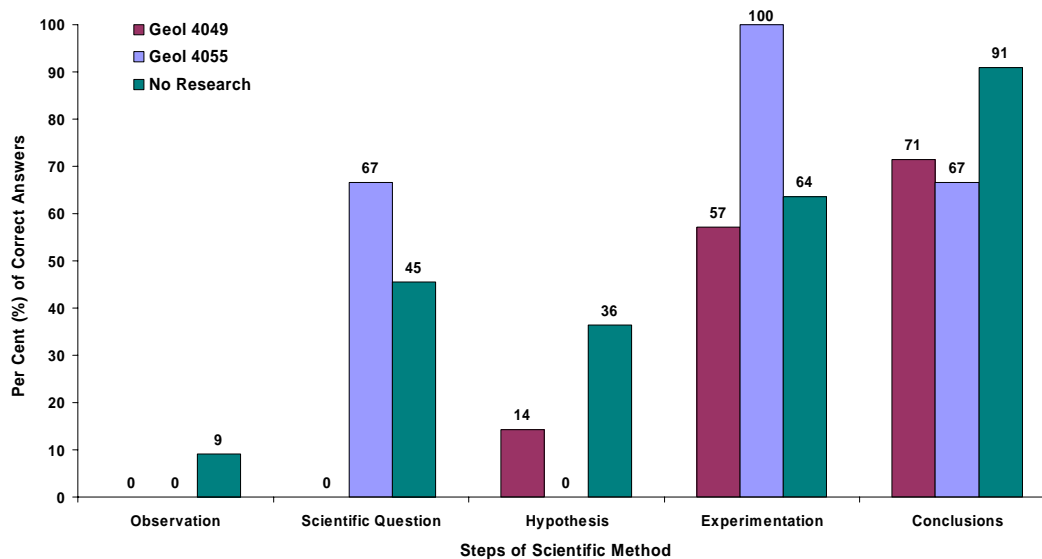


Figure 5: Correct answers during the post-test.

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The correct answers for the pooled data comparing the students with research courses and those without them are presented in Figures 6 and 7, respectively.

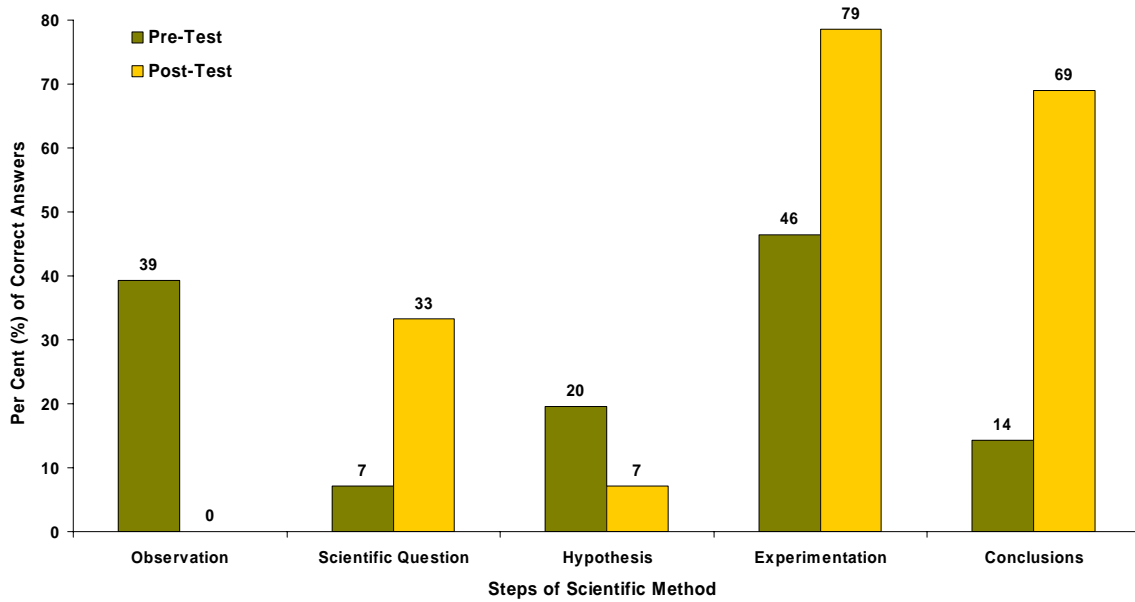


Figure 6: Correct answers from students with research courses.

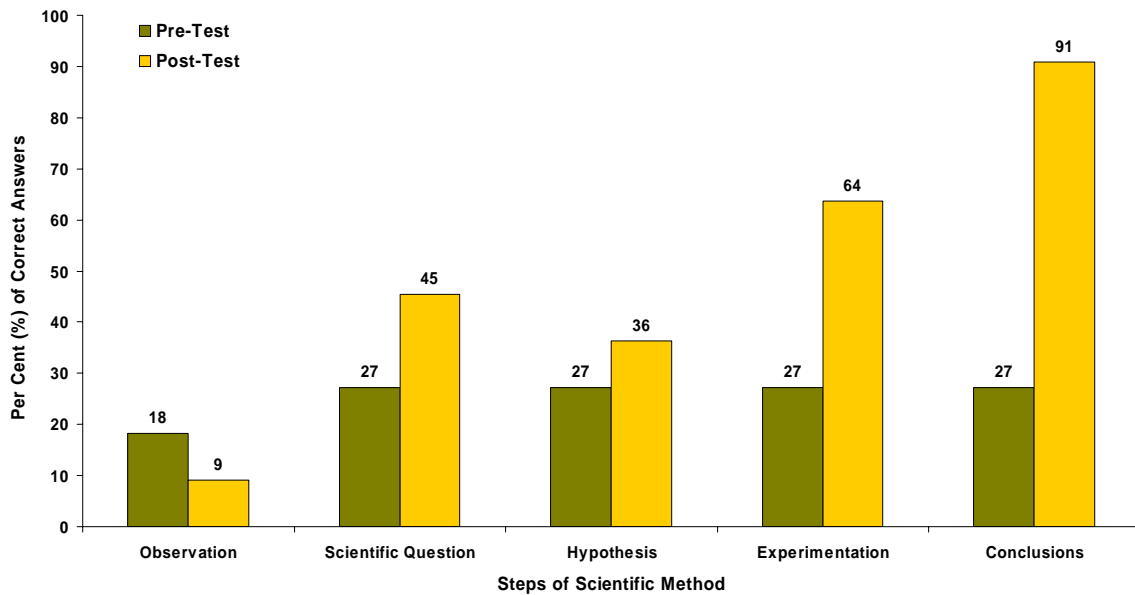


Figure 7: Correct answers from students without research courses.

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Results

- The number of students registered in undergraduate research courses (Geol 4049 and Geol 4055) has been increasing in recent years.
- These current trends demonstrate 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.
- 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
- Large differences were found between students registered in the first semester (Geol 4049) and those in the second semester (Geol 4055) for 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.
- 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.

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- 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 the students to identify the Observation and Hypothesis.

Possible Reasons or Hypotheses

The performed assessment project provided good results to better understand the impact of our undergraduate research courses in the learning experience of the Geology students. The clear trend of increasing students registered in these courses is directly related with the recent increase interest in the geological sciences. More students are enrolling in the Department and that was demonstrated in our previous assessment report. Since the students need to take two semesters of research, the amount of students per semester will continue increasing. The fact of having more students with the same amount of professors will require that each professor advises more students in the same amount of time, and perhaps with the same resources. This could affect the quality of education and the learning process. Therefore, fundamental changes to our curriculum are necessary in order to avoid these problems if the enrollment continues the current trend. It was clearly demonstrated that the research experience is very positive for our students, especially because it exposes them to new concepts, develops their analytical skills, and challenges them into new experiences. It was proved that it is necessary to maintain at least one research course in the curriculum of the Geology Department. However, the results show that no major differences are found between students with one and two semesters of research. This suggests that only one semester of research could be enough to significantly impact the learning process of our students. If this is the case, the curriculum should be changed in order to only require Geol 4049 and leave Geol 4055 as an option to those students that really like doing research and perhaps to those that are planning to continue to graduate school. The assessment also demonstrated that it is necessary to develop a workshop of the scientific method for those students registered in research. This initial training will help them to understand the research process and develop more focused projects. It will also help them to be more efficient and effective if they need to take only one semester.

Course of Action

- Review the structure of the undergraduate research courses, 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).

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Next project of learning assessment

- 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.

SECTION III: Appendices

The following documents are included in this report:

- Questionnaire to students taking the undergraduate research courses.
- Pre- and Post-tests given during the workshop of the scientific method.
- Oral presentation of the scientific method.

GEOLOGY UNDERGRADUATE RESEARCH
Assessment form to be completed by the student
Semester: 1st Year: 2004-2005

Student Information

Years at UPRM: _____

Major when admitted to UPRM: _____

Semester of Research: _____ Geol 4049 _____ Geol 4055

Description of Research Topic

How did you choose the topic? _____

The selected topic is related to:

- | | | |
|--|---|---------------------------------------|
| <input type="checkbox"/> Sedimentology | <input type="checkbox"/> Petrology | <input type="checkbox"/> Paleontology |
| <input type="checkbox"/> Volcanology | <input type="checkbox"/> Structural Geology | <input type="checkbox"/> Geophysics |
| <input type="checkbox"/> Geomorphology | <input type="checkbox"/> Seismology | <input type="checkbox"/> Hydrogeology |
| <input type="checkbox"/> Stratigraphy | <input type="checkbox"/> Remote Sensing | <input type="checkbox"/> Other: _____ |
| <input type="checkbox"/> Mineralogy | <input type="checkbox"/> GIS | |

Research Experience

In a scale of **1** (strongly disagree) to **5** (strongly agree) assess your experience in undergraduate research in geology.

Criteria	1	2	3	4	5
A well defined project with clear goals was assigned					
Faculty was accessible and helpful					
Learned the scientific method					
Applied knowledge from my geology courses					
Became exposed to new concepts					
Developed analytical skills					
The experience was challenging					
Improved my writing skills					
Improved my oral skills					
Gained confidence in my abilities to do research					

Would you be interested in continuing the same research in the future?

Yes _____ No _____ If not, why? _____

Comments concerning this research experience:

EL MÉTODO CIENTÍFICO

Área de interés para investigación: _____ Año de estudios: _____

¿Ha tomado algún curso de investigación? _____ Geol. 4049 _____ Geol. 4055 No

¿Conoce el método científico? Sí No

Para los siguientes resúmenes haga un círculo en la o las oraciones que considere corresponden a las siguientes partes del método científico y colóquele la letra correspondiente.

A-Observación

D-Experimentación

B-Pregunta Científica

E-Conclusiones

C-Hipótesis

ABSTRACT #1: Developing a protocol to use remote sensing as a cost effective tool to monitor contamination of mangrove wetlands

The characteristic of vegetation to react to the geochemical conditions of the substrate, has found a use in the remote sensing techniques applied to mineral exploration, where large areas can be efficiently surveyed without expensive field studies. Metal content in the soil changes the leaf reflectance, which is usually expressed as the Normalized Difference Vegetation Index (NDVI), and can be measured using a spectroradiometer in the field and the red and near-infrared bands in satellite images. The proposed study will test the use of remote sensing techniques of mineral exploration to the monitoring of mangrove wetlands for the presence of heavy metal contamination. The low diversity of mangrove vegetation makes them well-suited for this technique. Similar as in mineral exploration, a cost effective technique that does not require costly field studies, will make an excellent tool for government agencies in charge of monitoring the health of wetlands. Five mangrove wetlands were selected, to test the method, including Joyuda Lagoon (suspected natural Ni-Co contamination), the San José Lagoon (reported Pb, Hg, and Zn contamination), and Guayanilla Lagoon (Hg contamination) and two assumed pristine mangrove forests. Chemical analyses were carried out of substrate and leaves of the top of the canopy. Reflectance of the leaves were determined and heavy metal content and NDVI were correlated and incorporated to a Geographical Information System (GIS) showing the location of contaminated areas. A protocol was obtained, where on the basis of image analysis, areas of possible heavy metal contamination can discerned and summarized in a GIS. These areas should become high priority areas for field checking for possible pollution. The method proves to be successful and new training sessions and workshops using the remote sensing techniques and the GIS protocol were organized.

ABSTRACT #2: Understanding life on earth: molecular comparison of cyanobacteria present in the green layer of two tropical hypersaline microbial mats at the Cabo Rojo Salterns of Puerto Rico

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.

PRE PRUEBA

EL MÉTODO CIENTÍFICO

Área de interés para investigación: _____ Año de estudios: _____

¿Ha tomado algún curso de investigación? _____ Geol. 4049 _____ Geol. 4055 No

¿Conoce el método científico? Sí No

Para los siguientes resúmenes haga un círculo en la o las oraciones que considere corresponden a las siguientes partes del método científico y colóquele la letra correspondiente.

A-Observación

D-Experimentación

B-Pregunta Científica

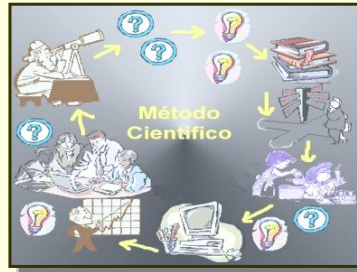
E-Conclusiones

C-Hipótesis

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POST PRUEBA



El Método Científico

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¿QUÉ ES EL MÉTODO CIENTÍFICO?

- **Proceso en el cual se usan experimentos para contestar preguntas.**
- **Es el modo ordenado de proceder para el conocimiento de la verdad, en el ámbito de determinada disciplina científica.**
- **Un conjunto sistemático de criterios de acción y de normas que orientan el proceso de investigación.**
- **El mecanismo que utilizan los científicos a la hora de proceder con el fin de exponer y confirmar sus teorías.**
- **Es la herramienta que usan los científicos para encontrar las respuestas a sus interrogantes.**



EN RESUMEN ...

Podemos concebir el método científico como una estructura, un armazón formado por reglas y principios coherentemente conectados. Los cuales aseguran que la ciencia avance al verdadero conocimiento de las cosas.



PASOS DEL MÉTODO CIENTÍFICO



1. Observación

2. Preguntas



3. Hipótesis



4. Experimentación



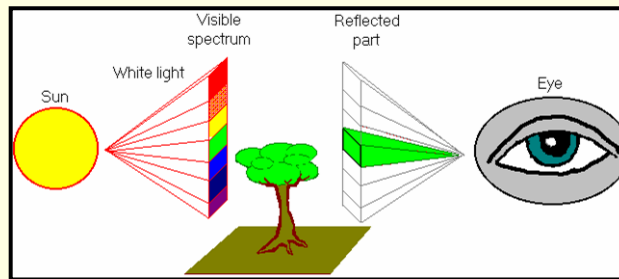
5. Conclusiones





OBSERVACIÓN

- La observación consiste en fijar la atención en una porción del Universo.
- Mediante la observación nosotros identificamos realidades o acontecimientos específicos del cosmos a través de nuestros sentidos.



PREGUNTA

- Una vez que se ejecuta la observación, surgen una o más preguntas generadas por la curiosidad del observador. La pregunta debe ser congruente con la realidad o el fenómeno observado, y debe adherirse a la lógica.
- El investigador siempre debe tener en cuenta que las preguntas que comienzan con un "por qué" son muy difíciles (si no imposibles) de contestar.
- El investigador objetivo prefiere comenzar sus preguntas con un "qué", un "cómo", un "dónde", o un "cuándo". La pregunta podría ser también un "para qué es".
- *Por ejemplo, ¿Cuál es la causa por la cual las plantas se ven verdes?*



HIPÓTESIS

- ***Luego, el observador trata de dar una o más respuestas lógicas a las preguntas. Cada respuesta es una introducción tentativa que puede servir como una guía para el resto de la investigación. Estas soluciones preliminares a un problema son las HIPÓTESIS.***
- ***Hipótesis es una declaración que puede ser falsa o verdadera, y que debe ser sometida a comprobación (experimentación). Los resultados de la experimentación determinarán el carácter final (falso o verdadero) de la hipótesis.***
- ***Por ejemplo, "Las plantas se ven verdes porque tienen un pigmento que refleja ese color".***



EXPERIMENTACIÓN

- ***Las predicciones son sometidas a pruebas sistemáticas para comprobar su ocurrencia en el futuro. Estas comprobaciones en conjunto reciben el nombre de EXPERIMENTACIÓN.***
- ***La experimentación consiste en someter a un sujeto o proceso a variables controladas.***
- ***La experimentación puede realizarse de diversas maneras, pero la experimentación controlada es una característica propia del método científico.***
- ***En experimentación controlada debemos tener dos grupos de prueba: un sujeto llamado grupo de control o grupo testigo, y otro llamado grupo experimental. El grupo de control y el grupo experimental, son sometidos a las mismas condiciones, excluyendo la variable que se ha elegido para el estudio.***



CONCLUSIONES

- **Luego de la experimentación la hipótesis original es evaluada y se determina si es verdadera o falsa.**
- **Además se evalúan los resultados a base de su alcance espacial y temporal en el cosmos.**
- **De acuerdo a eso se puede concluir si hemos llegado una teoría o ley.**



TEORÍA

- ***La Teoría es una declaración parcial o totalmente verdadera, verificada por medio de la experimentación o de las evidencias y que sólo es válida para un tiempo y un lugar determinados.***
- **Por ejemplo, “La clorofila hace que las plantas se vean verdes y le ayuda a fabricar su propio alimento durante la fotosíntesis”.**
- **Si la teoría se verificara como verdadera en todo tiempo y lugar, entonces es considerada como *LEY*.**



LEY

- Una teoría está sujeta a cambios, una ley es permanente e inmutable. *Una ley es comprobable en cualquier tiempo y espacio.* Sin embargo, una teoría es verdadera sólo para un lugar y un tiempo.
- Por ejemplo, la Evolución (de las plantas) es una teoría que se perfecciona de acuerdo a nuevos descubrimientos
- Mientras que lo relacionado con la Gravitación es una ley, pues ocurre en todo tiempo y lugar del universo conocido.

EL MÉTODO CIENTÍFICO ES UN PROCESO CONTÍNUO

