“Integrating innovative techniques in library science and guided inquiry based Science learning through undergraduate student self-directed primary research: A new approach.”

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Resumen. We have introduced an inquiry based, student centered mode of instruction in a general Science introductory course of first year Odontontology. Students have acquired course’s competencies by designing and carrying out their own primary research in a dentistry topic of their choice conducting a cross sectional statistical study. We have analyzed student’s perception of their academic gains and preference for chosen method of instruction: 65% of students report to have experienced an overall growth in their academic experience, and 80% feel the experience has been challenging but worth the effort. We have also looked at the role that the language of instruction has played in this process: 75% of students perceive it as a positive aspect although adding difficulty specially when dealing with such a heterogeneous population. Based on this year’s findings we propose improvements in course organization and instructional strategies.

Palabras clave: Inquiry based learning; student centered instruction; primary research

INTRODUCTION (CONTEXTUALIZATION/ RATIONALE)

The USA National Science Educational Standards focus on the development of scientific literacy in students and promote Inquiry as the “central strategy for teaching science” (National Research Council, 1996). Inquiry forms part of a quality Science experience. “Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (Singer, 2006). Effective Science-Inquiry programs have the potential to prepare both teacher and student in a way of learning that promotes scientific literacy and critical thinking habits of mind. (National Science Teachers Association (NSTA), 2007).

The main three competencies or performance skills to be developed in any undergraduate science introductory course can be summarized as follows:
1. Skills related to documentation and library science. Students should be able to gather, evaluate and use appropriate (level wise and topic wise) sources of information. When using these sources, agreed upon referencing rules should be used consistently.
2. Students should be able to use the Scientific Method.
3. Students should be able to identify and implement the Scientific Publication steps and the scientific article.

Generally these courses are taught following a traditional lecture based method. There has been an overall observation of the following issues:
- Students are unable to critically evaluate sources of information and end up working
with many low quality secondary research types of work, from mainly inappropriate websites and non-scientific magazines.
- There is a worrisome level of plagiarism.
- Students are not able to apply and work with the scientific method.
- Students are not able to manage working with scientific journals within their field of work.

These findings are not uncommon within Science teaching in university circles. Researchers advocate for a more student centered approach which includes, especially amongst others, inquiry based activities within science topics based on the fact that there is a considerable number of students that do not perform well following traditional teaching methods (Brew, 1995). In spite of these findings, there are not many instances where science introductory courses at the university level encourage true student led research or that go beyond a few instances of cooperative learning activities and a few isolated case studies. However, true undergraduate research is widely considered an effective tool for enhancing the overall undergraduate experience (Lopatto, 2004).

Many benefits are described in different studies such as increased interest in a career in science, increased levels of pursuit of graduate education and an overall increased ability to gather information, carry out research and speak efficiently (Bauer, 2003).

On the other hand, Science students currently find themselves with unprecedented access to information (Flaspohler, 2007). Different studies show that many times students struggle to locate and use reputable sources of information and use them to write research papers (which is a common requirement for all Science undergraduates) (Flaspohler, 2007).

Following these findings, we propose to integrate innovative techniques in library science and guided inquiry based Science learning through undergraduate student self-directed primary research. We have been using different educational techniques in “Documentation and Introduction to Research Methods in Odontology” which is a mandatory course for all Odontology students at the UEM, currently taught in English in the first semester. Continuous techniques, results and findings developed along this research study, will be also applied in “Fundamentos Bioquímicos, Biológicos y Fisiológicos”, a mandatory annual course, currently taught in Medicine Degree first course.

**Our working hypothesis** is that enhanced library science instruction integrated as part of a student led primary investigation (following the guided inquiry mode of instruction), within one of the content subjects that students are currently studying, effectively lead to true acquisition basic competencies and higher student satisfaction. Our project lies within the priority lines of this University as we are moving from Innovation to Research in Education. We have implemented the inquiry based model of teaching during the first semester of 2010-2011 in Documentation and Introduction to the Scientific Method in Odontology. Based on our findings during this semester we will introduce changes in the same course the following year and in “Fundamentos”, a first year Medicine course.
OBJECTIVES

- Generating student centered activities which we are able to evaluate using rubrics to lead to a better assessment of resources available to students and application of citation regulations.

- Planning curriculum following inquiry based model where students plan and conduct primary scientific research accurately.

- Doing an internal university publication of student scientific papers, following the publication requirements as presented by the ICMJE (International Committee of Medical Journal Editors) and all format requirements of Scientific Journals. In this process second year students will be recruited to serve as part of an editorial board, as well as faculty members of subjects involved (Epidemiology, Pharmacology and Biochemistry, where other inquiry and research-based learning experiences have been successfully achieved (Knutson, 2010)).

- Increasing collaboration with Library staff at UEM in order to improve bibliography management by students and to reduce plagiarism.

METHODOLOGY

The technique we followed to structure the course falls under the structure of what is considered a guided inquiry structured mode of instruction. We can highlight the following strategies which were applied sequentially:

Initially, small scale activities were developed to introduce certain skills that would be needed by each group of students to later on carry out their independent research projects.

- Introduction to the concept of Research in Odontology.
- Introduction to sources of information thorough a workshop done with UEM Library staff to start students on research strategies.
- Activities to learn how to evaluate appropriate vs. inappropriate web sources.
- Extensive work on Medical data bases like Medline and other resources available through the Library´s website.
- Primary vs. secondary sources of information.
- Cooperative learning activity to develop secondary research project on a Scientist of their choice focusing on the Scientist´s position and influence in the history of Science. The objective of this activity was to have students work in teams in order to develop work strategies following rubric specifications. During this project Vancouver method of citations was introduced. Evaluation of this project served to establish rigour standards in terms of plagiarism, adherence to work specifications and in particular referencing and citation regulations.
“Paper project” was introduced following the sequence below:

- Students were advised to group themselves in research teams following certain criteria: interest in the same odontology topic, ability to work together in terms of logistics and work style and academic objectives.

- In their groups, students picked an Odontology topic of their choice and conducted an extensive Literature review which needed to include at least three relevant, current scientific articles and college level books on the topic chosen. Students, this way gained background knowledge to facilitate the planning of their primary investigation.

- Students were handed a “Proposal Outline” designed by the professor, in order to guide the steps of their investigation plan. First year Odontology students also study Epidemiology during the first semester. Considering the time frame and financial and practical possibilities of the students a set mode of research was set for all projects: a cross sectional survey. This was given to them as they would be able to plan a rigorous investigation question that would be answered either through population surveys or through data from their parents’ dental clinics (in this case it was strictly requested that they present original evidence of patient consent to use their information). In the proposal outline, students needed to include summaries of the literature review process, the objective of their investigation, the original survey they were planning to perform or the data they were planning to collect from the clinics. In addition, they were asked to think about and outline how they were going to organize the data collected and how it would be analysed in terms of statistical analysis.

- A strict deadline was fixed to hand in the proposal and several feedback sessions and tutorials were set up to guide students through the process. An approved proposal granted permission to start with the survey, analyse the data and write the paper. Making sure that there is evidence of a continuous and monitored process (through logs of team progress maintained by the professor) guaranteed the authenticity of the study.

- Once the proposal was approved, students conducted their research, surveys and analysed their data. In this process they were informally advised by their epidemiology professors through individual tutorials. This constituted a multidisciplinary effort.

- In order to write the final paper a very specific rubric was developed summarizing the requirements of the ICMJE (International Committee of Medical Journal Editors) and we worked with model scientific papers several sessions.
• Students wrote their papers independently but were encouraged to email and discuss drafts through communications with the professor and a team leader per group.

• UEM Library staff collaborated with class professor to introduce the program Refworks to manage citations in a more effective and accurate manner.

• Students communicated their findings both through very structured oral presentations (one of the competencies/skills, please see figure 3) to be developed in the class and through written papers.

DESCRIPTION OF EXPERIENCE AND RESULTS

In order to try to assess this experience in the most objective way possible we will concentrate on the following:

In Results of student questionnaires which aim to gather the experience of the learner:

• The questions try to identify difficulties students have had with the course being completely in English.

- Even though 50% of Odontology first year students have an English level below level 6, as per the UEM English Lab, 76% of students reported it as a positive aspect that the course is taught in English. However, many students make the following suggestions:
  
  • "There should be an option to course the class in English or Spanish according to the students level of English"
  
  • "It is very difficult to be in the same class where there are English levels which go from level 1 to bilingual, and even more challenging to work in such a heterogeneous group".

- As professors, we feel the same challenges than the students, but agree on the overall benefit of having the course in English. As a future focus of research we could attempt to group students according to their English level to see if we can get better results or higher student satisfaction. However, this would present a problem in the way to assess groups of students who are truly unable to express themselves in English and write a full report in English. Another aspect worth noting is the high frustration levels generated by the difficulty of communicating with students who literally cannot understand. This is a specially challenging task with large group of students.

![Figure 1. Student’s perception of English as the class’ working language](image)
• The academic gains students feel they have gained as learners doing an independent primary research paper. Almost 70% of students feel they have grown positively as a result of this experience.

![Overall academic graph](image)

Figure 2. Student’s perception of academic growth as a result of the course.

• The effect that being able to choose an odontology topic to do their research on has had on their motivation and interest level. There was a clear increase in student’s interest when starting the project, and what they perceived as an area not related to their field (documentation and research) turned into an area of their interest by doing their own research. Many students chose implantology, oral hygiene habits and different types of oral disease.

![Free selection of topic graph](image)

Figure 3. Student’s view on having been able to choose their own topic.
- About 80% of students have found writing the paper as a positive experience; 28% found it difficult but worth it, whereas almost 60% found it very interesting.

- Learners have been asked to identify preferred methods of instruction.

![Experiences writing the paper](image)

**Figure 4. Student’s perception about writing the scientific paper.**

![Preferences for Instructional Strategies](image)

**Figure 5. Student’s preference for instructional methods.**
• We have also analysed grade results for each group of final multiple choice exercise, paper grade and the final grade of the class. We wanted to see if students perform within the same ranges with a project and in a multiple choice test. We feel it ethically controversial to create a control group of students who would have a completely traditional mode of instruction, more traditional, and compare the academic results with the other group with the inquiry based mode of instruction. Moreover, we do not have available data which would be comparable to try to evaluate the effectiveness of this method over others, since last year this Documentation course was taught in Spanish by different professors, each with different evaluation methods. The multiple choice exam is designed to assess the main competencies outlined in the course objectives. With our percentages we hope to give a general idea of how the course proceeded. The overall percentage of passing students is 68%, the average grade for the paper is 6, 6 and the average exam grade is 6, 03. We feel that the comparable grade range between the exam and the paper reflects the fact that students were able to apply the knowledge gained during the research process and that the paper grades were fair and students truly collaborated in their research groups.

• We would like to note that we analysed the grades of group T14. This group of students started with four students and kept admitting students well into the semester, as late as two month after course started. The average grade for the paper for these students is 5, 2. We want to emphasize that in any student centered activities students must play a crucial role in the process.

CONCLUSIONS

• The first reflexion that as professors we would like to make is about the language of instruction, English. In agreement with the student opinion there are many benefits of having instruction in English, some intrinsic with the objectives of the course and some not. If we look at the English levels of the students as a whole, there are a considerable number of student with level below 6 (see figure 1). For these students any opportunity to practice more is beneficial, but we feel that this is at the expense of jeopardizing complete understanding of course objectives. Keeping their whole career in mind, due to the high volume of medical literature in English, it only makes sense to introduce this course and no other in English.

• It is clear that allowing students to play a central role in the learning process results in higher levels of satisfaction, having 80 % of students reported to have grown academically.

• Majority of students advocate for alternatives to traditional modes of instruction; although many report a higher level of stress during class sessions. Many have
also highlighted the oral presentations as one of the biggest but most useful activities. We feel that once again, having had clear expectations and guidelines for the activity really serves to increase student achievement and motivation (please refer to figures 1 and 5).

- Looking at the results of group T14, which had students progressively join the course at different points in the project, we can see the effects that this has on the performance

- Gathering students observations and our own, we would like to make the following improvements for next year:
  - Increase the hours per week of instruction for the course. We will move from two hours per week to three. We believe that this will allow closer facilitation of the project and will lead to easier management of high volume of students (last year one professor managed 220 students).
  - We will try to make smaller groups of students to ease the logistics of doing the research and writing the paper.
  - We will use internal funding to purchase different reference books that students can use in class and borrow.
  - We will add an editing component to the process done by students. We will also prepare an internal publication which will gather all student papers and will form a board of editors from second year students who will also facilitate the process.
  - We will compare these years results with next year’s as we continue to grow looking at our own practice.

REFERENCES


