Is IBL (Inquiry based learning) Helping Zayed University Students Acquire Scientific Skills In A General Science Course?

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Abstract The purpose of this work is to investigate if higher education students can develop scientific skills throughout the learning process supported by the approach of inquiry based learning (IBL). This method has been known to be a process where students have the chance to formulate questions, investigate to look for answers and earn new meanings and knowledge. This study suggests that IBL has considerable potential to create a non-traditional community for educational purposes. With the use of the IBL approach, Zayed University students have shown a good improvement within the area of scientific skills, and most important of all, students have shown a high level performance and course satisfaction.

Keywords: Scientific skills, Inquiry based learning approach (IBL), General education course.

Introduction

In the last two decades, higher education has known great changes, the main thrust in teaching is more on professional programs rather than knowledge based programs, and therefore a lot of concerns toward teaching effectiveness have been raised within many educational institutions around the world.(Biggs & Tang, 2011) In this regards, many approaches have been developed to improve the quality of higher education, to convert learning from teacher centered to student centered and to adopt interactive methods.(Justice, Rice, Roy, Hudspith, & Jenkins, 2009) These approaches have used several methods such as problem solving, problem based learning, project based learning and inquiry based learning.(Smith, Sheppard, Johnson, & Johnson, 2005) All these approaches suggested that opportunities for gaining a good understanding in higher education could be achieved via courses that use interactive methods.(Egenrieder, 2007) In fact, these comprehensive strategies allow students to work in groups and conduct investigations of real world topics. Students usually work over extended period of times to solve challenging questions or problems. Therefore students would be involved in the process by: designing and conducting investigations, gathering information, collecting data, asking questions, drawing conclusions based on their results and reporting their findings toward the end of their work.(Brickman, Gormally, Armstrong, & Hallar, 2009)

Inquiry-based learning (IBL) is a pedagogical approach, developed in 1960 as a trial to enhance new instructional methods against traditional forms of instruction that were primarily based on memorization.(Bruner, 1961) The main idea behind IBL is that students can generate information themselves and make sense out of it. Students are engaged with the content or the material, and come up with questions and investigate. The meaning constructed from an experience or experiment can be concluded individually or within groups.(Bächtold, 2013; ROTH & Jornet, 2014) The process of using the IBL approach involves many steps such as: developing questions, making observations, searching for related information, designing experiments and collecting data, analyzing and interpreting data, and finally concluding and outlining possible explanations and developing recommendations for future studies.(Haury, 1993) For science education, a lot of criticism was made about the fact that science courses were taught in a way that does not encourage thinking. John Dewey, a well-known scholar in the field of education, was the first to propose at the beginning of the 20th century that science should be presented to students as a process and way of thinking rather than a subject with facts to be memorized.(Loucks-Horsley & Olson, 2000) Furthermore, science courses lend by nature to investigation and collection of data, therefore the IBL approach was firstly adopted within the sciences' community.(Bianchini & Colburn, 2000; Crawford, 2007; Wood, 2003)

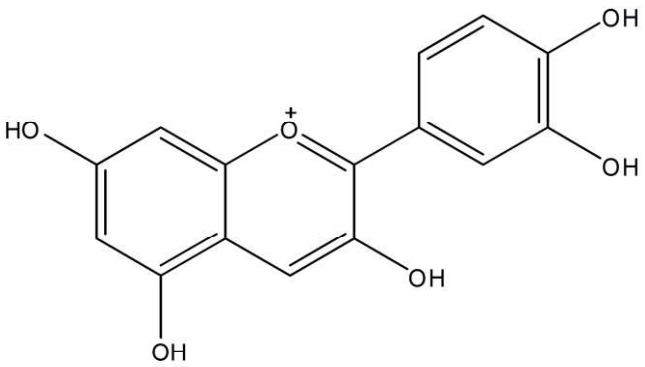
The main goal of this study was to investigate the important effect of IBL in promoting sciences' learning within undergraduate students' population at Zayed University. Students performance in the second

required science course (The introduction to the environemtal sciences) has been compared with that of students who did not take the first IBL science course. Three methods were used to evaluate the ouput of the study: class observation, grade's comparison and students' survey. And the reseeach results revealed that achievement in a general education science course of undergraduate students significally improved with the acquiring of sciences skills via inquiry based learning approach.

Study method

The sample of the study conducted at Zayed University, Dubai campus, UAE, consisted of a total of 77 (four sections) female students from the general education level (COL 165 course: The nature of science discovery). The inquiry based learning approach was used for a non- major introductory science course taken by all undergraduate students to fulfill the science general education requirement. The course was normally scheduled to meet two times a week for a period of 80 minutes each time. Course sections had in average 19 students. And, over consecutive semesters (Fall, spring and summer) of the academic year 2013-2014, data were collected. The students of the general education science course needed first to work on different scientific classroom activities that helped them acquire different scientific skills. They have started learning how to formulate scientific questions, how to make good qualitative and quantitative observations. Then the focus was to learn throughout designed activities how to come up with possible explanation by trying to find answers (Conjectures). Students then have been guided to come up with a testable hypothesis and to design experiments that will allow them to provide evidence for their chosen hypothesis. In this specific phase of the IBL course, students needed to be introduced to different types of variables (dependent variables, independent variables, fixed variables and controlled group). After few activities, where students had the chance to practice the above skills within a chemistry, physics or biology frame, they were able to start conducting scientific experiments. Students were ready to collect data, analyze and interpret it and conclude. Around the middle of the semester, students were ready to start working on a scientific project. Students were given the chance to choose a topic on their own, and start their scientific investigation. This assessment component has helped students put what they learned in action (Knowledge in action) and investigate something that interest them (Ownership of knowledge).

Example of scientific activities: The IBL approach is mainly based on designed activities where students learn through inquiries and investigating theses inquiries. For instance, one example of class activities conducted in the COL 165 course at Zayed University within the chemistry frame of the course, consisted on investigating the color change of a cyanidin solution. The main objective of the activity was to help students formulate scientific questions, make qualitative and quantitative observations and come up with conjectures. Students were given first cyanidin solution and they needed to add it to other different solutions. Students needed to come up with a question that implies the relationship between the cyanidin solution and the color change. After that, students needed to investigate more the chemical concept of the color change by trying specific solutions (Acid and alkali). At this moment, students started to come up with observations that address the link between the color change and the acidity of the solution. Most of the observations highlighted the fact that when cyanidin is added to acidic solutions, the color change is different compared to when the same cyanidin was added to alkali solutions. Yet within the same acidity, the color change was the same. At this phase of the activity, students needed to come up with conjectures and therefore needed to use their prior knowledge or start a search on the subject. At the end of the activity and based on the inquiry based learning approach, students had learned independently about indicators, natural indicator and artificial indicators, solution acidity, color change and pH. At this specific activity, students did not investigate further the color change concept, their main focus was not yet to provide evidence, it was rather to investigate based on formulating questions, making observations and coming up with conjectures. Later on during the semester, students needed to work on various investigations by using other skills that include hypothesis, experiment design, data collection and others.



Structure de cyanidin: 2-(3,4-Dihydroxy-phenyl)-3,5,7-trihydroxy-chromenylium

Study evaluation: Throughout the semester, general education students were observed inside the class and their involvement in various course activities (COL 165) was closely followed up. In addition, and toward the end of the fall semester, students were asked for their feedback concerning the course. Furthermore, and during the following semesters (spring and summer), grades of students who have taken the first science course (COL 165) then the second science course (COL 260) were investigated and a comparison between the performance in the second science course was conducted between this population of students and another population of students who took the second science course without taken the first science course. The figure below shows different component of the study's methodology.

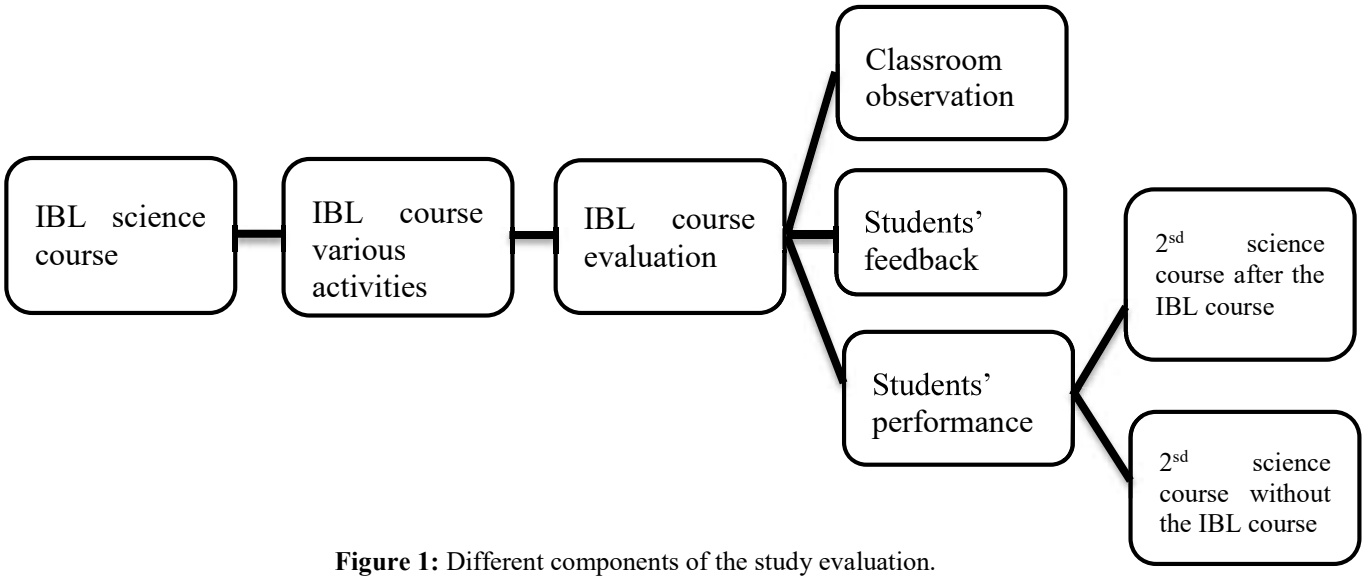


Figure 1: Different components of the study evaluation.

Results and discussion

In higher education, it has been proven that the success of using the approach of IBL within the instructing process is based on the practice nature of knowledge and learning, on the nature of the different activities, and finally on the knowledge integration. All of that has proved to overcome challenges of the learning process for university students. Using IBL, students normally use the scholarly and research practices to engage in a discipline or interdisciplinary activities or problems in a learning environment rich of challenge and support.(Li & Zhao, 2015) In a traditional general education science course, undergraduate students usually are presented with the contents of three different disciplines (chemistry, physics and biology). Different scientific concepts are discussed, and each part of the course is followed by a test. In the redesigned form of the course developed in Zayed University using the IBL approach, students need to work continuously to acquire scientific skills throughout various activities inside and outside the class. The assessment is not test driven, rather it is mostly based on scientific activities performed inside the class and an individual project. Achieving success in each part of the IBL course provided students with self-confidence and brought motivation and enthusiasm for the course.

In this work, the main objective behind using the inquiry based learning in a science subject, is to prove that designing course activities that are relevant and interesting can practically provide students with good opportunities to become independent learners. The students' population involved in this study is non-science major that implies that students had various levels at sciences and quantitative background. Teaching this heterogeneous group of students is known to be a very challenging task. However, if the IBL approach is used, every one of these students will be given a chance to contribute, and to develop skills depending on her abilities and understanding. Furthermore, and in addition to students acquiring many scientific skills, students can in parallel develop the skill of working with a clear objective (Knowledge in action) as well as the skill of working within groups. The first part of the study evaluation conducted in Zayed University in the Dubai campus, was based on classroom observation. Students' involvement in various activities inside the class has shown a positive improvement throughout the semester. Students have seemed to like different practical activities where they needed to work on their own and take responsibility of their own learning. Figure 2, shows that a good percent (64%) in the COL 165 course have loved working in different activities inside the classroom. Only 9% of the COL 165 students seemed not to agree about the usefulness of these various class activities. This finding is expected, as many students resist the change and like to learn in the same way previous generations had learned.

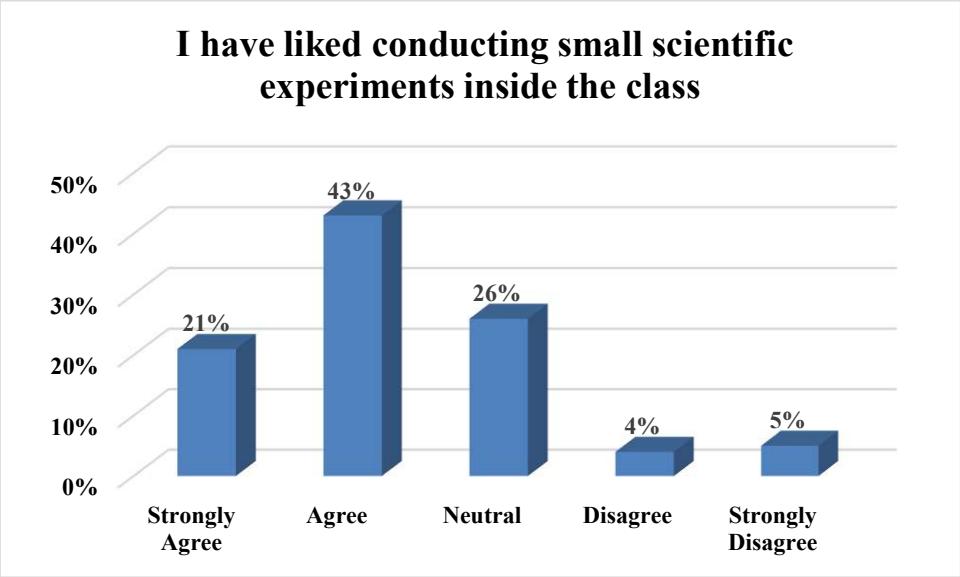


Figure2: Data reflecting students' involvement inside the class.

The second part of the study concentrated on evaluating the impact of the scientific skills that students have acquired in the COL 165 course on their performance in the second science course they need to take (COL 260) during the following semesters (Spring or summer). These students' performance was compared to that of students who did not take COL 165 but took directly COL 260. The table below presents grades comparison.

	Without COL165	With COL165
A	2%	28%
B	25%	43%
C	55%	15%
D	16%	13%
F	2%	2%

Table 1: Grades data for two categories of students. The first category forms students who have taken directly COL 260. The second category forms students who have taken COL 165 first then COL 260.

The table shows that students who have taken COL 165 course first then COL 260, as part of their sciences' requirement of the general education courses in the university, had performed better compared to students who took directly COL 260. The number of students who got A in the second science course has positively changed from 2% to 28%. The percent of students who got B in COL 260 has jumped from 25% for students who took directly the course as opposed to 43% for students who took first COL 165 then COL 260. For students who got C the number have dropped from 55% to 16%, and finally the number of students with D has dropped from 16% to 13%. This data that was collected from students who took COL 165 first during fall 2013 then COL 260 during spring- summer 2014 (64 students). The COL 260 data of students who did not take COL 165 was based on previous entries of students' grades during fall 2012, before the new science course was offered for general education students in Zayed University. The performance comparison shows clearly that students who took COL 165 first had performed better.

The last part of the study was based on student's feedback. At the end of the 2013 fall semester, an online survey was conducted for four sections of COL 165 of an average of 77 students. Figure 3 presents an example of students' answers.

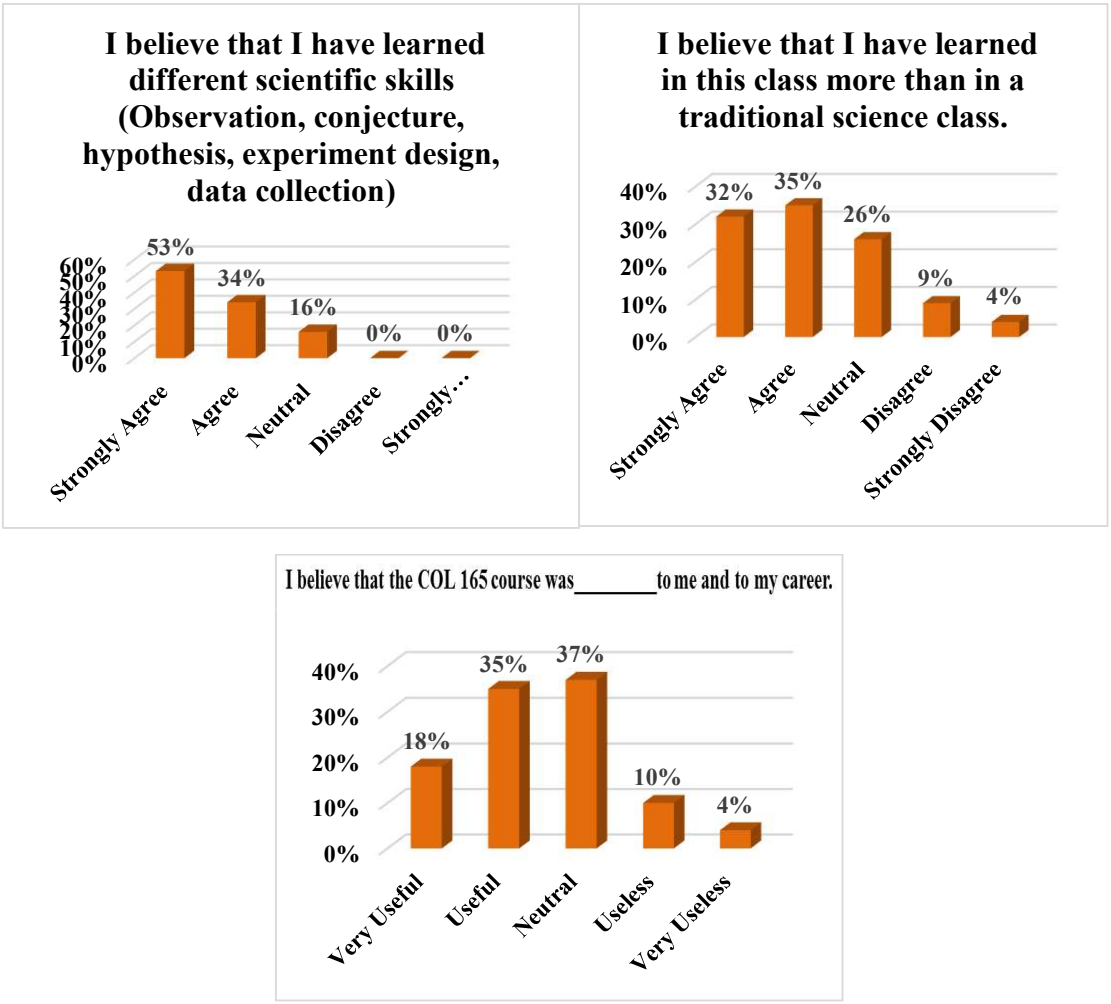
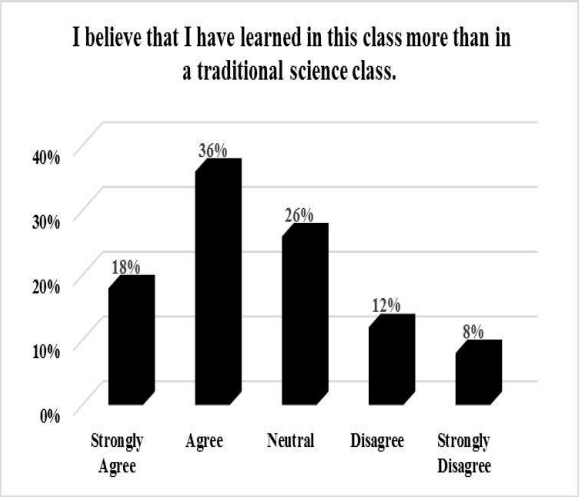


Figure 3: Students' feedback as per the COL 165 course. The online survey was conducted toward the end of the semester (Fall 2013)

The data shows that students were mostly positive about the IBL science course. Around 87% of students either strongly agree or agree about the fact that the course allow them to acquir scientific skills. A percent of around 70% believed that they have learned sciences in the IBL course better than in a traditional science course. Finally around 53% of students thought that the IBL science course was useful and would help them in their careers, while 37% of these students were neutral about that. As explained previousely, that will always be a population of students who would resist the change and would prefere to learn in a traditional teacher centered environment.

In addition to asking students for their feedback in my own sections (77 students in four different section of the COL 165 course). Students' feedback from other sections of the same course was used and a population of 50 students was asked for their feedback toward the end of spring 2014. Interesingly, similar patterns were obseved. Infact, across different sections of the COL 165 course, around 72% of students believed that IBL allowed them to acquire scientific skills. Students of different sections (54%) said that they have learned in the IBL medium more than a traditional environment. A percent of 46% thought that the IBL course was useful to them as well as to their carreers. Below is an example of students' feedback obtained from other COL 165 sections during spring 2014.



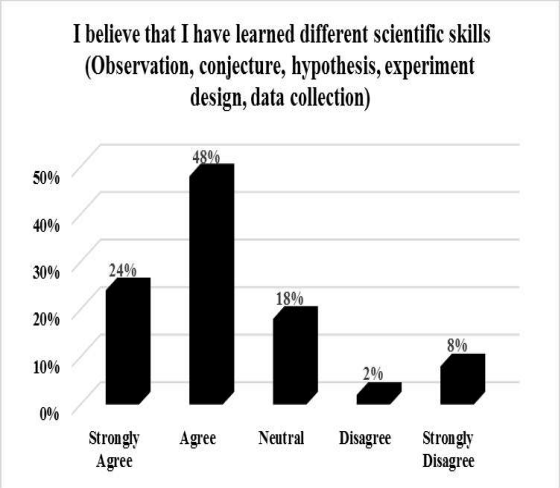


Figure 4: Students' feedback as per the COL 165 course. The online survey was conducted toward the end of the semester (Spring 2014)

Conclusions

This study has shown that inquiry based learning is an effective pedagogical approach in which students engage in intellectually challenging work that allow them to gain knowledge and skills. At Zayed University, IBL has enabled students of the first general education science course to work on real scientific cases, to quantify their funding and to comprehend the process of using the scientific method to investigate or solve a problem. The IBL course was designed to provide students with enjoyable and effective activities. Students have put their knowledge in action, they have practice how to make quantitative and qualitative observations, how to come up with good and relevant conjectures, how to make a testable hypothesis, how to design experiments to provide evidence for their hypothesis, how to collect data, analyze and interpret it and finally how to conclude. Students had afterwards the chance to practice these skills on an individual project of their own. The study evaluation has shown that the IBL approach was overall a positive experience for the general education students, classroom observation, students' performance and students' feedback has proved that university courses can be a good area for students to acquire scientific skills as well as knowledge in an interactive and student centered model. The approach should be used though carefully as skills can overtake the knowledge area of the course, therefore, classroom activities and different components of the course should be designed in a way that balances skills and knowledge. Finally, Zayed University can create an autonomous life-long learning environment by: Identifying learning objectives, employing non-traditional learning approaches such as IBL, using appropriate resources, training its faculties and spreading the awareness of the importance of the learning opportunities that exist inside classrooms.

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