Problem-Based Learning for Healthy Hearts

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Abstract: New content has primarily been introduced through lectures in content-heavy science courses. Students are often disengaged in this teacher-centered instructional method. Currently, there are few published studies on the effect of problem-based learning (PBL) in high school science classes in the United States. The purpose of this action research study is to evaluate the effectiveness of PBL module in a blended learning environment to increase concept attainment in high school students at a private high school on O‘ahu. Students worked in teams of three to four to complete a set of tasks relating to the cardiovascular system while role-playing as medical assistants at a fictitious cardiology clinic. In addition, students were asked to complete a pre-module and a post-module survey. Results indicate that students successfully learned new concepts in regards to the cardiovascular system. Students found the scenario-based tasks to be engaging and fun while learning applicable concepts pertaining to the human cardiovascular system.

Introduction

High school teachers face a challenge to deliver content that is engaging and motivating to their digital native students. Many science classes tend to be content heavy and still rely on traditional lecture-based instruction to teach new concepts. Problem-based learning (PBL) is a relatively new pedagogy method first started at the medical school at McMaster University in Canada in the 1970s. It is a constructivist, learner-centered method that strives to engage students in real-world problems (Boss, 2011). Scenario-based PBL takes the student-centered process a step further in providing an authentic self-directed learning environment (The Experiential Learning Center, n.d.). Many educators see PBL as a modern spin on the Socratic method.

This is the researcher’s second year teaching Anatomy and Physiology. Even though it is a one semester elective course, it is still content-heavy. Previously, I introduced new topics for each body system to students by lecturing while presenting information on PowerPoint slides. I have found students to be disengaged and furiously writing, rather than processing the information presented. Problem-based learning has been shown to have positive effects on students’ motivation, engagement, and concept attainment (Wirkala & Kuhn, 2011). As many science teachers are still struggling to deliver content

effectively, this action research study will determine whether PBL is an effective method in helping high school students with concept attainment in content-heavy science courses.

The purpose of this action research study is to evaluate the effectiveness of PBL in a blended learning environment to increase concept attainment in high school Anatomy and Physiology students at a private high school on O‘ahu. The expected outcome for this study is that PBL will help students gain an understanding of the human cardiovascular system while working collaboratively in a team to solve a series of tasks culminating in solving a given medical case.

Literature Review

In undergraduate science education, some universities are moving away from traditional lecture-based learning to integrate more problem-based learning in teaching content. Carrió, Larramona, Baños and Pérez (2011) looked at effectiveness of hybrid problem-based learning (H-PBL) in teaching biology at undergraduate level in Spain. The results showed that a H-PBL course did not impede or enhance the students’ ability to recall factual knowledge compared to a traditional lecture-based course (LBL). Content acquisition seems to be the same for H-PBL and LBL. There seems to be more student satisfaction in the H-PBL group.

Other studies in undergraduate science courses demonstrate that PBL enhanced learning while fostering critical-thinking, problem-solving, and collaborative skills (Marklin Reynolds and Hancock, 2010 and Tatar & Oktay, 2011). The results showed improvement and greater achievement in problem-solving skills through PBL. Additionally, students perceived learning through authentic PBL method to be more effective, more permanent, more enjoyable than traditional lecture-based learning.

In a study conducted on first-year medical students on their conceptual understanding of the cardiovascular system, researchers found that PBL greatly improved the students’ ability to recall and describe an accurate model of the cardiovascular system (Mikkila-Erdmann, Sodervik, Vilppu, Kaapa, and Olkinuora, 2012). Working in small groups in the PBL setting helped students become aware of their misconceptions as well as encouraged peer coaching. Researchers also found attitudinal surveys to be effective in collecting data regarding students’ perception of PBL.

The above studies in post-secondary courses agree that PBL has a positive effect on improving students’ motivation, engagement, and retention of concepts. There is a consensus to start PBL earlier, to implement PBL as early as elementary education. Also, many of these studies take place outside of the United States. Currently, there are few published studies on the effect of PBL in high school science classes in the United States. Hence, this study was designed to analyze the effectiveness of PBL in a high school science course in concept attainment of new materials without front-loading with lecture-based instruction.

Research Questions

Problem-based learning is still a relatively new instructional method in high school. To investigate the effectiveness of PBL for concept attainment in a high school anatomy class, this action research project aims to answer the following questions:

- What are students' perceived attitudes towards PBL in general?
- What are students' perceived attitudes towards long-term group work as part of the PBL module?
- What are students' perceived attitudes about concept attainment using PBL?
- How effective was PBL in concept attainment?

Project Description

Researcher Information and School Environment
The sole researcher of this action research study was one of three Anatomy and Physiology teachers at a large private high school in Honolulu. The researcher was responsible for 2 sections out of 4 taught in the fall semester.

Project Participants
The learners in this action research study were high school students ranging from grades 10 – 12 at an independent K-12 school on O'ahu. All students had MacBook laptops connected to the school's wireless network. The laptops were equipped with computer software needed for their classes – Safari, iMovie, Microsoft Office, Acrobat, iPhoto, etc. They are digital natives with prior experience navigating through the school's course management system. Participation in this study was voluntary. Participating students were required to submit a signed assent form and a signed consent form by their parents.

Research Methods
The methodology involved students working collaboratively in a PBL project in a blended learning environment while learning the basics of the cardiovascular system. Students role-played as "newly hired medical assistants" with the instructor/researcher acting as a "training supervisor" at a fictitious cardiology clinic. Students worked in teams of three to four to complete a set of tasks relating to the cardiovascular system. Students used a variety of web 2.0 tools throughout the project to help plan, design, and develop their ideas and understanding. The course was hosted on Haiku Learning Management System (Haiku LMS) and required the use of several web 2.0 tools, such as Wiki Projects, Google Docs, and VoiceThread. This action research project took 4 weeks of one-and-a-half hour classes, meeting every other day, to implement in the classroom.

Surveys
A pre-module survey and a post-module survey were created prior to the implementation of the PBL module. Students were asked to complete these surveys so comparison could be made regarding concept attainment before and after the PBL module. In addition to demographic questions, the pre-module survey contains 4 Likert-scale questions

regarding instructional methods and group projects. The post-module survey asked 14 Likert-scale and open-ended questions to provide opinions on the PBL process and skills needed for group projects. Both surveys were completed via Google Forms.

Observations and Data Collections
Artifacts such as students' Wiki Projects, Google Docs, and VoiceThread presentations have been gathered to evaluate the effectiveness of the PBL project in meeting its goals. Other data include classroom observations and the scores from the cardiovascular unit test.

Results

The PBL module was implemented on October 25, 2012 and ended on November 28, 2012, taking place over the part of the second quarter for the 2012-2013 school year. Students were informed of the purpose of the project and that participation was voluntary. Thirty-four out of 35 students in the two sections of Anatomy and Physiology participated in this study. Of the 34 students, 27 were female and 8 males. All have taken Biology in 9th grade and have either previously taken or concurrently taking Chemistry. More than half (57%) are seniors, 34% are juniors, and 9% are sophomores.

Based on the pre-module surveys, students rated the following methods of instruction as being highly effective for them: lectures, whole/small group discussions, demonstrations, cooperative or team-based learning, and labs or hands-on activities. They rated role-play and student peer teaching as being mediocre as methods of instruction. Fifty percent of students also reported that they feel neutrally regarding long-term group projects. The results of the post-module survey is summarized in Table 1 as well as categorized by research questions.

Table 1. Percentages of participants who agreed or strongly agreed on the post-module attitudinal survey (n=34).

Questions	
I found it helpful for this Cardiovascular PBL Unit to be based on a real-life company. It made learning the cardiovascular system more real to me.	78%
I think problem-based learning is a good way of learning new material.	75%
I feel very confident about the knowledge I gained from this cardiovascular unit.	63%
PBL should be used in other courses too.	69%
Did you learn new concepts about the cardiovascular system from this unit?	97%
Did you enjoy working with a team in this unit?	91%
Did you feel that your team worked productively during class time?	91%
Did you find the tasks to be interesting?	94%
Working in groups was a waste of time	15%

What are students' perceived attitudes towards PBL in general?
Based on the pre-module survey, only a quarter of students have had exposure to problem-based learning in previous courses. From the post-module survey, 75% of students found PBL to be a good way of learning new material. Sixty-nine percent of students say PBL should be used in other courses too.

What are students' perceived attitudes towards long-term group work as part of the PBL module?
According to the post-module survey, 91% of students enjoyed working with a team during the PBL module. The same number (91%) felt that their team worked productively during class time. Eighty five percent of students disagreed with the statement "working in group was a waste of time".

What are students' perceived attitudes about concept attainment using PBL?
All but one student agreed with the statement that they "learned new concepts about the cardiovascular system from this unit." About two-thirds of the students feel confident about the knowledge they gained from the cardiovascular unit. Throughout the 4-week period, students were active and interested. They enjoyed the scenarios-based tasks and working in fictitious cardiology clinic. One student stated, "I liked these PBL projects because they made me feel very official and like a real scientist. I enjoyed working in a group and using research to figure out the problem."

How effective was PBL in concept attainment?
Overall students scored well on the four tasks/deliverables assigned during the PBL module (Figures 1, 2, 3). The mean for Task 2, cardiovascular vital signs report, was 87.5%. The mean for Task 4, mystery case presentation on VoiceThread was 96%. The mean score on the cardiovascular unit test was 87%.

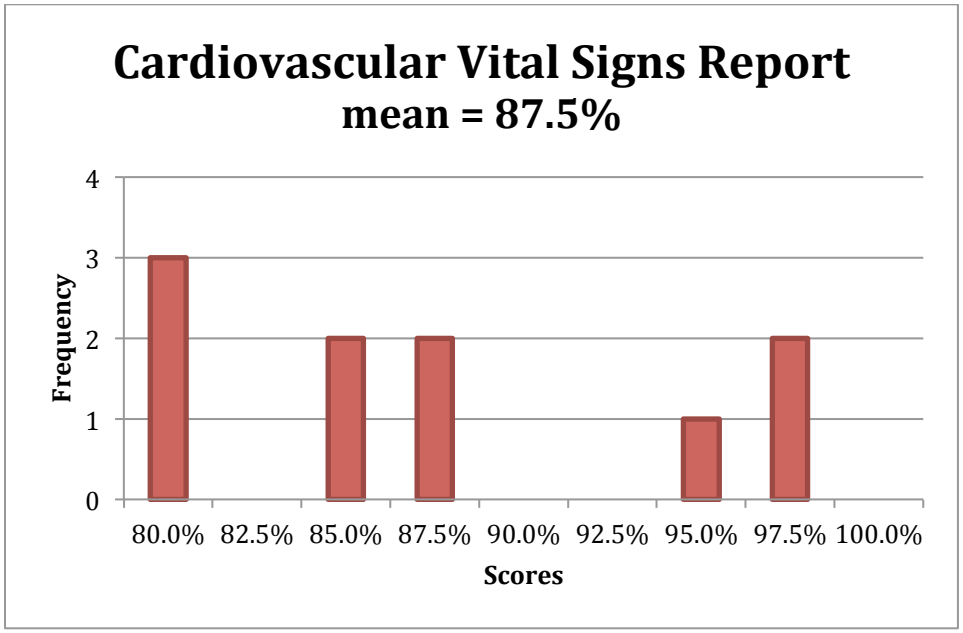

Figure 1. Task 2 scores showing team scores on cardiovascular vital signs report.

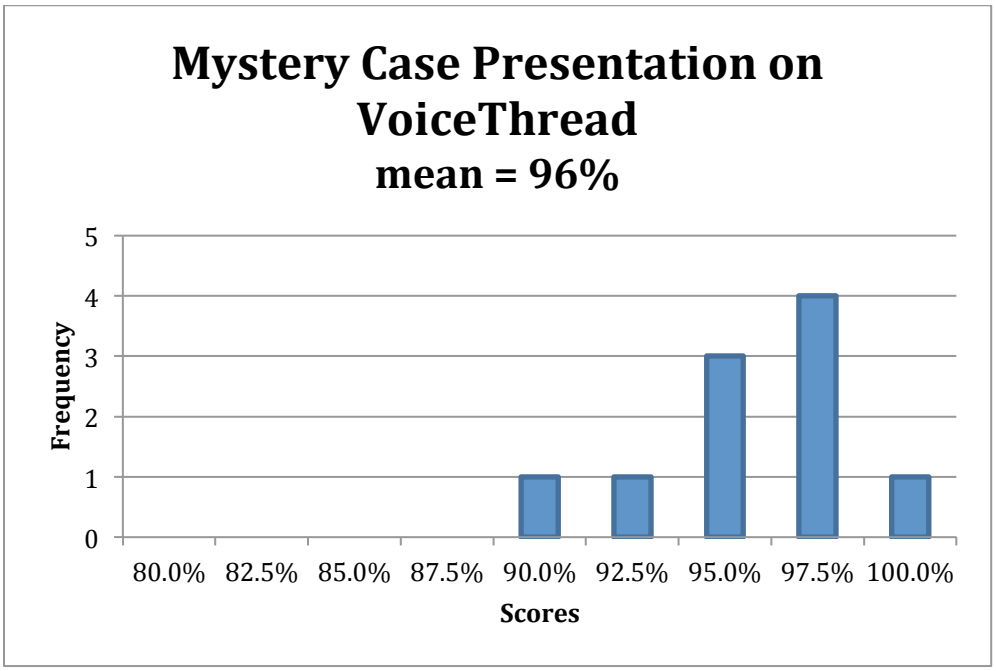

Figure 2. Task 4 scores showing team scores on mystery case presentation on VoiceThread.

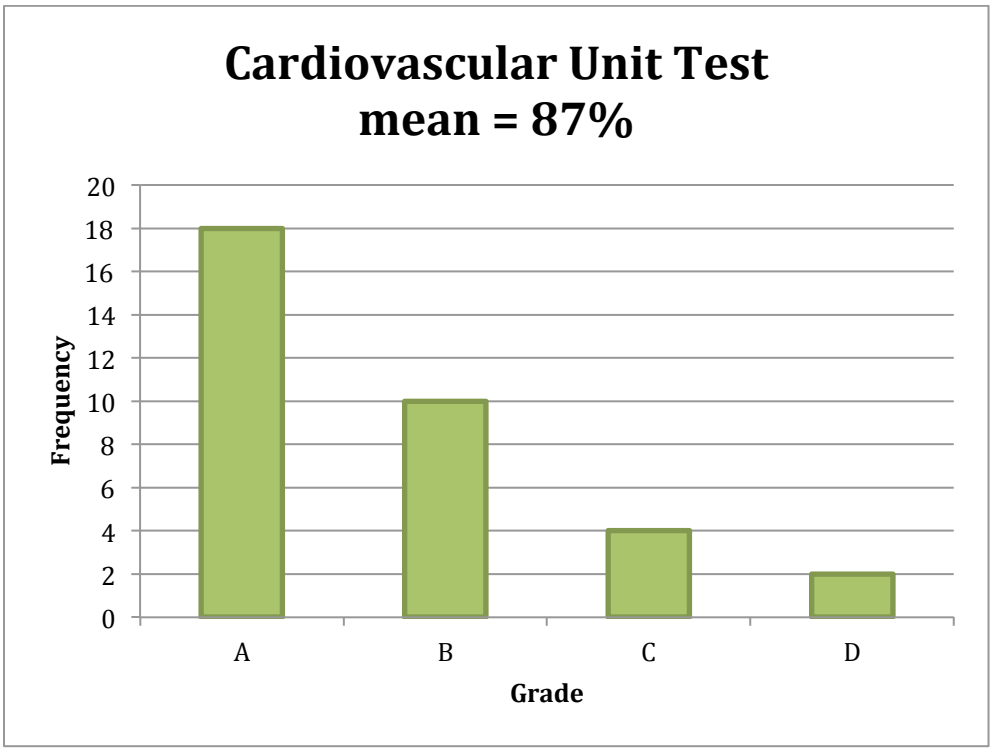

Figure 3. Students' scores on cardiovascular unit test.

Discussion

Students in this study successfully learned new concepts in the cardiovascular system using PBL. Overall, the implementation of the module went smoothly. It helped that students had already been using Haiku LMS for two months and had already had experience using the Wiki Projects feature of Haiku LMS. The debrief at the end of each tasks helped students internalize their learning and reflect on what they had learned.

Some of the challenges encountered include the retention and breadth of concepts attained. Since each member of the team was responsible for only one aspect of the task, each student did not have a chance to learn in depth about other parts of the cardiovascular system. For example, in each team, one student was responsible for drawing the model of the heart and demonstrating her understanding of the anatomy of the heart. However, this student might not have had as thorough an understanding of the pathway of the blood through the body since it was another member's responsibility. One student states, "We all split up our parts during the tasks so we knew much much much [sic] more information about the part we had to complete than the other parts. We all did a good job providing information, but it was hard to try and learn the other parts when there was so much information. So when it came to the test, I wasn't sure what I needed to really know and what I didn't just because there was so much information."

There were also some issues with group work. One particular group did not work well together due to conflict in personalities. It may help to have students choose their own groups rather than randomly assign groups. Additionally, a contract may be drafted by each team with clear roles for each group member.

A majority of students had difficulty with scientific writing for Task 2. Although a checklist and rubric were given to students for each task, scores for Task 2 were lower than I would have liked. Additionally, students had not had much exposure to scientific writing since their term paper in 9th grade Biology. To address this issue in the future, I plan to chunk out the assignment into smaller parts with teams turning in drafts for peer feedback. It might be helpful for students to see a well-written report in comparison to a poorly written report as reference as well.

Lastly, upon reflection, the unit test does not truly assess what students have learned in this problem-based learning module. In many ways, the true assessment is Task 4 where students solved a medical mystery case relating to a cardiovascular disorder. Many students felt rightly that they were not adequately prepared for the unit test. About a quarter (9/34) students would still prefer to have some lectures in place rather than having everything be problem-based as reported on the post-module survey. This summative assessment relies on factual recall of the heart anatomy and major heart disorders.

Conclusion

This study shows that students do attain new concepts through PBL. Students appreciated having the project be scenario-based. The results of this study in regard to students' performance and attitudes toward PBL are in line with findings of previous studies (Carrió et al., 2011, Marklin Reynolds & Hancock, 2010, Tatar & Oktay, 2011) with one exception. Students do not seem as well prepared for factual recall on summative assessments through PBL in this study. It could be that students need more time to dialogue with one another and the content through PBL compared to traditional lecture-based instruction.

Wood (2003) puts it best that "PBL does not offer a universal panacea for teaching and learning in medicine." However, this study shows that PBL can be an effective way to teach new materials in Anatomy and Physiology. It fosters collaboration, communication, student engagement, and motivation. Students are responsible for their own learning and create products demonstrating higher orders of thinking. The real-world application and authentic tasks help to engage students while "sneaking" in the content. As one student reflected, "there are good and bad parts of working in problem-based learning, but it really does put a lot more responsibility of learning on the student."

Anatomy and Physiology being an elective course, scoring highly on summative assessments is not as important as a core science course. Students who tend to take Anatomy and Physiology are in the top tier of their class and are interested in pursuing a career in medicine – thus, factual recall is a factor students strive towards. To address this need, short PowerPoint lectures with key points can be incorporated with the PBL activities for a blended-PBL module. This way, students may reap the benefit of both authentic learning of PBL and factual recall of lecture-based instruction.

References

Boss, S. (2011). Project-Based Learning: A Short History. *Edutopia*. Retrieved March 16, 2012, from http://www.edutopia.org/project-based-learning-history

Carrió, M., Larramona, P., Baños, J. E., & Pérez, J. (2011). The effectiveness of the hybrid problem-based learning approach in the teaching of biology: a comparison with lecture-based learning. *Journal of Biological Education (Society of Biology)*, *45*(4), 229–235. doi:10.1080/00219266.2010.546011

Marklin Reynolds, J., & Hancock, D. R. (2010). Problem-based learning in a higher education environmental biotechnology course. *Innovations in Education & Teaching International*, *47*(2), 175–186. doi:10.1080/14703291003718919

Mikkila-Erdmann, M., Sodervik, I., Vilppu, H., Kaapa, P., & Olkinuora, E. (2012). First-year medical students' conceptual understanding of and resistance to conceptual

change concerning the central cardiovascular system. *Instructional Science: An International Journal of the Learning Sciences*, *40*(5), 745–754. Retrieved September 4, 2012 from http://www.eric.ed.gov/ERICWebPortal/detail?accno=EJ975620

Tatar, E., & Oktay, M. (2011). The effectiveness of problem-based learning on teaching the first law of thermodynamics. *Research in Science & Technological Education*, *29*(3), 315–332. doi:10.1080/02635143.2011.599318

The Experiential Learning Center. (n.d.). *What is scenario-based learning?* Retrieved September 8, 2012, from http://learnpbl.com

Wirkala, C., & Kuhn, D. (2011). Problem-based learning in K–12 education: is it effective and how does it achieve its effects? American Educational Research Journal, 48(5), 1157–1186. doi:10.3102/0002831211419491

Wood, D. F. (2003). ABC of learning and teaching in medicine: Problem based learning. *BMJ : British Medical Journal*, *326*(7384), 328. Retrieved February 5, 2013 from http://www.ncbi.nlm.nih.gov.eres.library.manoa.hawaii.edu/pmc/articles/PMC1125189/