

Action Research Project

Using Case Studies, Hands-on Activities, and Simulations to Increase Cognitive Skills and Interest in High School Biology Students

Biomedical Explorations: Bench to Bedside

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Abstract

The purpose of this study is to use the case study method, hands-on activities, exposure to university materials, and simulations in order to enhance the cognitive skills and interest level of Biology Honors students. As incoming 9th graders, students may possess a negative attitude about science perhaps due to a lack of basic laboratory skills, and misunderstandings related to the nature of science. By exposing students to current research in biotechnology through the aforementioned methods this study seeks to change negative perceptions concerning science, and provide positive academic outcomes for students.

Rationale

This study took place in The School District of Hillsborough County at H.B. Plant High School. Hillsborough County is a recipient of the Bill and Melinda Gates Foundation Empowering Effective Teachers Grant. This grant stipulates that teachers are evaluated by both their principal and peer evaluator several times throughout the school year through an instrument developed by Charlotte Danielson (2007) from the second edition of her book *Enhancing Professional Practice*. I have been evaluated using this instrument and from my meetings with the evaluator have learned that the new instrument requires that the lesson be centered on objectives for learning. The pay scale of teachers will be directly tied to this instrument, and all teachers at Plant have been encouraged to embrace this new system of teaching objectives (Kunkle, 2010).

Plant was named one of Newsweek Magazine's top 50 high schools in the United States (Newsweek, 2010). The school has a high Socio-Economic Status with less than 15% of the school population being identified as economically disadvantaged. The school climate is one of hard work and a focus on excellence in both the academic and extracurricular areas. The classes chosen for this study

were Biology Honors. This course is comprised of a rigorous curriculum with an abundance of standardized-test style questions throughout the prescribed coursework and on the midterm and End of Course (EOC) exams. The students in my classes are taking the most difficult curriculum possible for their grade level at Plant High School. Most of these students were taking high school credit classes while in middle school in order to prepare for this class and provide a higher GPA than would normally be possible for a high school student (Kunkle, 2010). Because I have such high achieving students I chose to focus on improving both student cognitive skills and interest to my students via case studies hands-on activities, and simulations. I also hope to improve my delivery of instruction through the implementation of this study.

With the upcoming Biology end of course exam, science teachers are faced with the job of covering a multitude of topics our state deems relevant and hoping our students retain enough information to pass. The task seems daunting enough, but to make matters worse it is often accompanied by negative attitudes following an unhappy middle school experience in science courses, lackluster grades, or general apathy. One of the most innovative ways to overcome the barriers of negativity and to address the copious material in a way that enhances interest and allows students to retain material is by using a case study method or “inductive teaching” (Wood, 2009).

According to Wood (2009), there is great need for reform in the teaching of biology because America is losing competitive stature in the area of science, technology, engineering and mathematics (STEM). Wood goes on to suggest groups, formative assessment, and actively engaged students are responsible approaches for obtaining maximum results. These suggestions are a major focus of this action research, especially in regard to using case studies.

Because many students hope to enter the medical field in some venue, case studies seem to be a perfect teaching strategy as promoted by Popil (2011) in a recent article submitted to *Nurse Education Today* (2011). Additionally numerous authors propose using the case study method to “engage higher cognitive skills” (Guilford, 2009), “elevate understanding of concepts and improve reasoning skills” (Smith & Murphy, 1998), and produce an elevated sense of accomplishment (Bryant & Baggott la Belle, 2003). With this research in mind, the purpose of this study to determine if using the case study method, incorporating multiple biomedical topics, laboratory exercises, and simulations can show a measurable enhancement of interest and attitude in biology as well as improved cognition of relevant, state-tested concepts.

Action Research Intervention

Ninth and tenth grade Biology Honors students were provided with biomedical and biotechnical case studies, simulations, and activities that will not only increase cognitive skills, but also improve interest towards scientific concepts in general. Throughout the entire year, beginning with the Scientific Method through the study of the human body, relevant methods of case study have been utilized and assessed. Case studies were obtained through teacher research into current scholarly and news articles and later modified for the classroom and assigned as “bellwork” along with questions relating to the article (Appendix I). The focus of these case studies included emerging fields in biology, medical applications of biological organisms, and biology’s benefits to human civilization.

In addition to case studies, students have been provided with opportunities to complete online laboratory simulations through www.explorelearning.com. This is a district sponsored initiative that provides alignment with many biomedical concepts relevant to the curriculum. These are categorized into modules classified as GIZMOS. In addition to extra credit opportunities, students will attend one GIZMO session per month in the media center for a regular class work grade. Each GIZMO consists of

an introduction, worksheet, and quiz. The GIZMOs available to the student were selected by the instructor and aligned with district curriculum standards. These modules served the dual purposes of introducing students into virtual laboratory settings, and extending the school day beyond the classroom through technology.

The University of Florida and Hillsborough County Community College have conducted laboratories with Biology students. These institutions have provided valuable insight and resources that were unavailable at the school site. By providing high school students with highly structured and advanced laboratories instructors made strong connections to the importance of biotechnology and higher education. This connection was reinforced by permitting students to present posters at the annual Junior Science Engineering and Humanities Symposium (JSEHS).

The following are the state learning objectives addressed during the course of this research:

Biochemistry (October 6-14)

SC.912.L.18.2 (Honors Extension)

Describe the important structural characteristics of monosaccharides, disaccharides, and polysaccharides and explain the functions of carbohydrates in living things.

SC.912.L.18.3 (Honors Extension)

Describe the structures of fatty acids, triglycerides, phospholipids, and steroids. Explain the functions of lipids in living organisms. Identify some reactions that fatty acids undergo. Relate the structure and function of cell membranes.

SC.912.L.18.4 (Honors Extension)

Describe the structures of proteins and amino acids. Explain the functions of proteins in living organisms. Identify some reactions that amino acids undergo. Relate the structure and function of enzymes.

The Cell Cycle (October 17-November 9)

SC.912.L.14.1

Describe the scientific theory of cells (cell theory) and relate the history of its discovery to the process of science.

SC.912.L.16.14 EOC

Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.

SC.912.L.16.8 EOC

Explain the relationship between mutation, cell cycle, and uncontrolled cell growth potentially resulting in cancer.

Mendelian Genetics (November 15-December 9)

SC.912.L.16.2

Discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, codominant, sex-linked, polygenic, and multiple alleles.

HE.912.C.1.4

Analyze how heredity and family history can impact personal health.

SC.912.L.14.6

Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.

Connections to Bench to Bedside Summer Institute

- Science Takeout (Stem Cells)
- Science Takeout (Dichotomous Keys)
- JSEHS
- GIZMO simulations
- Case studies relating curriculum to real people and situations

Data collection and analysis

Data were collected using pre-made assessments based on the state curriculum; Data collection in the form of surveys, informal interviews with JSEHS participants, and data analysis of standardized assessments is included. For the purposes of this study the researcher has limited the data collection portion of the project to the first semester with the exception of those students attending JSEHS; however these activities did continue throughout the school year.

The survey polled 84 student participants using a likert scale. The survey included 17 questions that sought to measure student perceptions of science pre and post observation. The last five questions measured attitudes, learning, and understanding of science related to the interventions. Participants were provided with a ten point bonus for completing the survey, and 84 percent of all students participated in the survey.

Questions one and two of the survey measured the degree to which students favored science over other subjects pre and post Biology Honors. The graph below (Figure 1) shows that significant numbers of students became less interested in science during this project, while many became unsure of their favorite subject. This shift of favor away from science was not unexpected, but to determine the source of this change I asked probing questions to several students. The overwhelming response was that they would rather study a subject that was easier. All agreed that there was simply too much information to learn. Not surprisingly this perspective is shared by many teachers who feel that there is too much information to teach included in the current curriculum. However, the current curriculum is largely determined by the Florida Department of Education (FLDOE) as it determines the content assessed on the End of Course Exam (EOC). This limits the ability of teachers to tailor the curriculum to the interests and needs of the student.

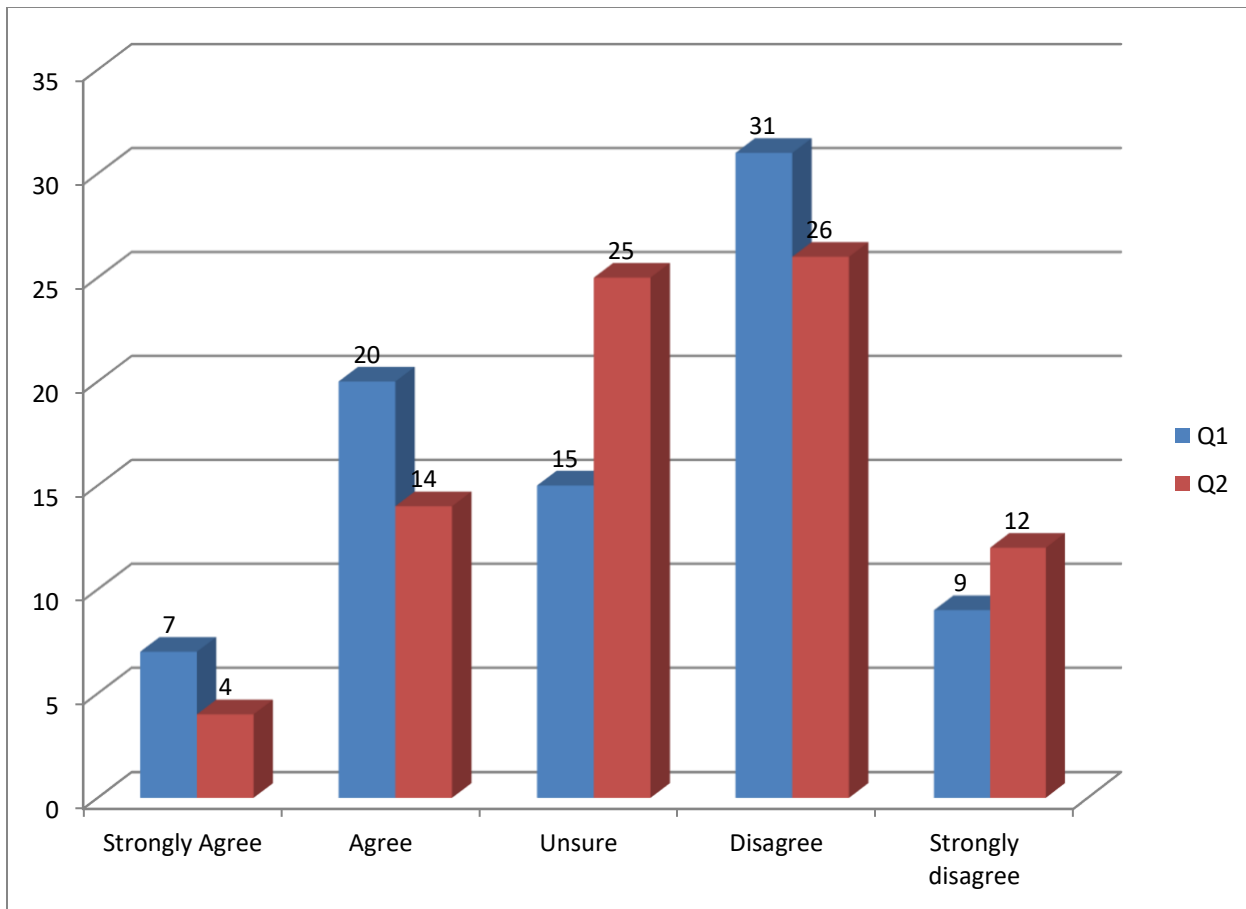


Figure 1

Questions three and four of the survey measured the degree of interest the participants had in studying science in college. Based on the pre/post results from question one it is not surprising that there was a slightly negative movement away from strongly agree (2 participants), with a slight increase in the numbers who agreed (2 participants) as seen in figure 2. Although it is clear that the majority of Biology Honors students show a lack of interest in science, an area of future research may focus on students who are interested in science. By determining the factors that motivate these students it may be possible to create the opportunity for less interested students to embrace science as a career choice.

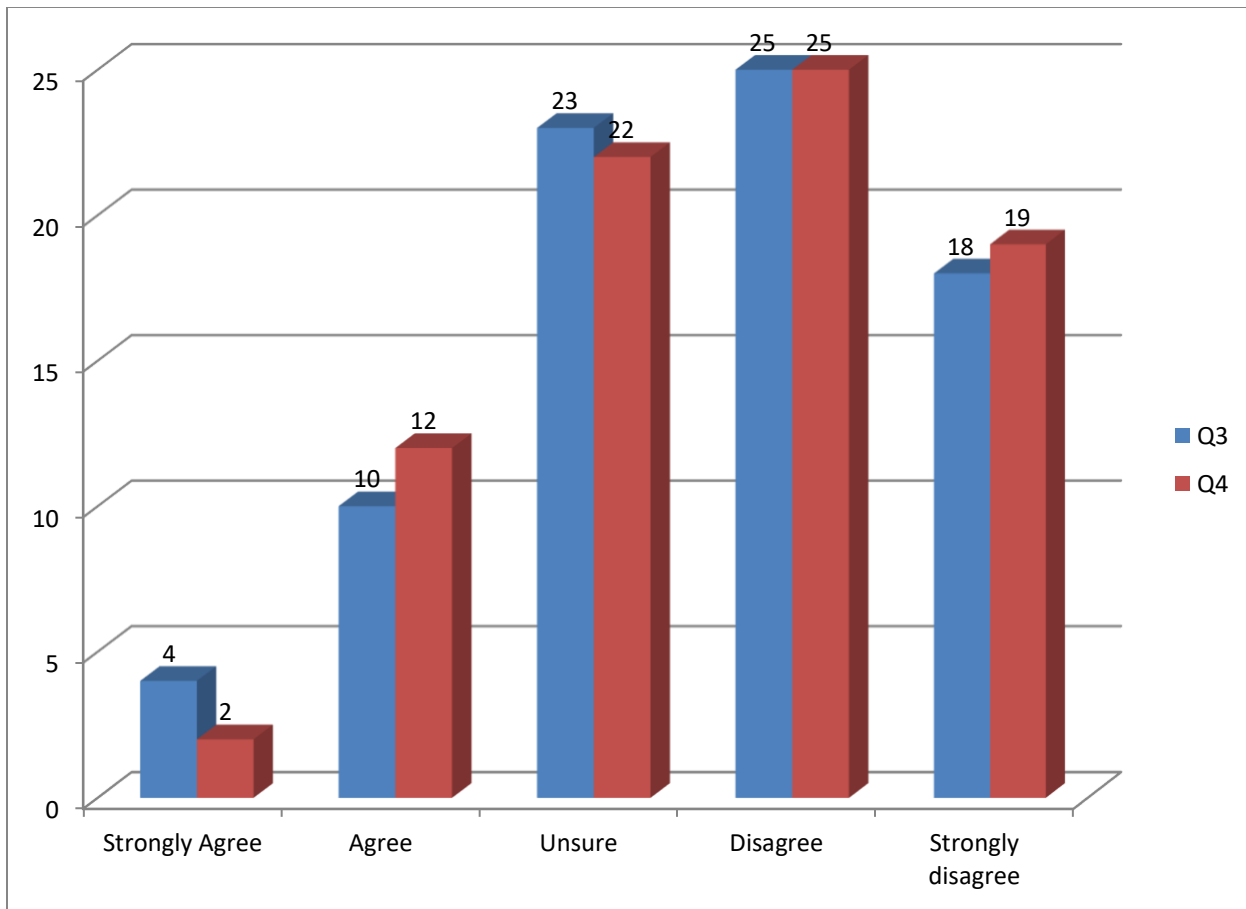


Figure 2

Questions five and six sought to determine the extent to which students enjoyed online laboratory simulations such as GIZMOS. Figure 3 clearly shows that few students had been exposed to online simulations or their experiences had been largely negative prior to Biology Honors. Additionally there was a positive shift that indicated students enjoyed these simulations. When asked, positive respondents to question five indicated that GIZMOS had been used in their middle school as a pilot program the previous year. Access to GIZMOS is limited due to a lack of computer labs in our school, and student access to internet from the home. Eight GIZMOS were formally conducted during this project; however bonus GIZMOS were available for extra credit.

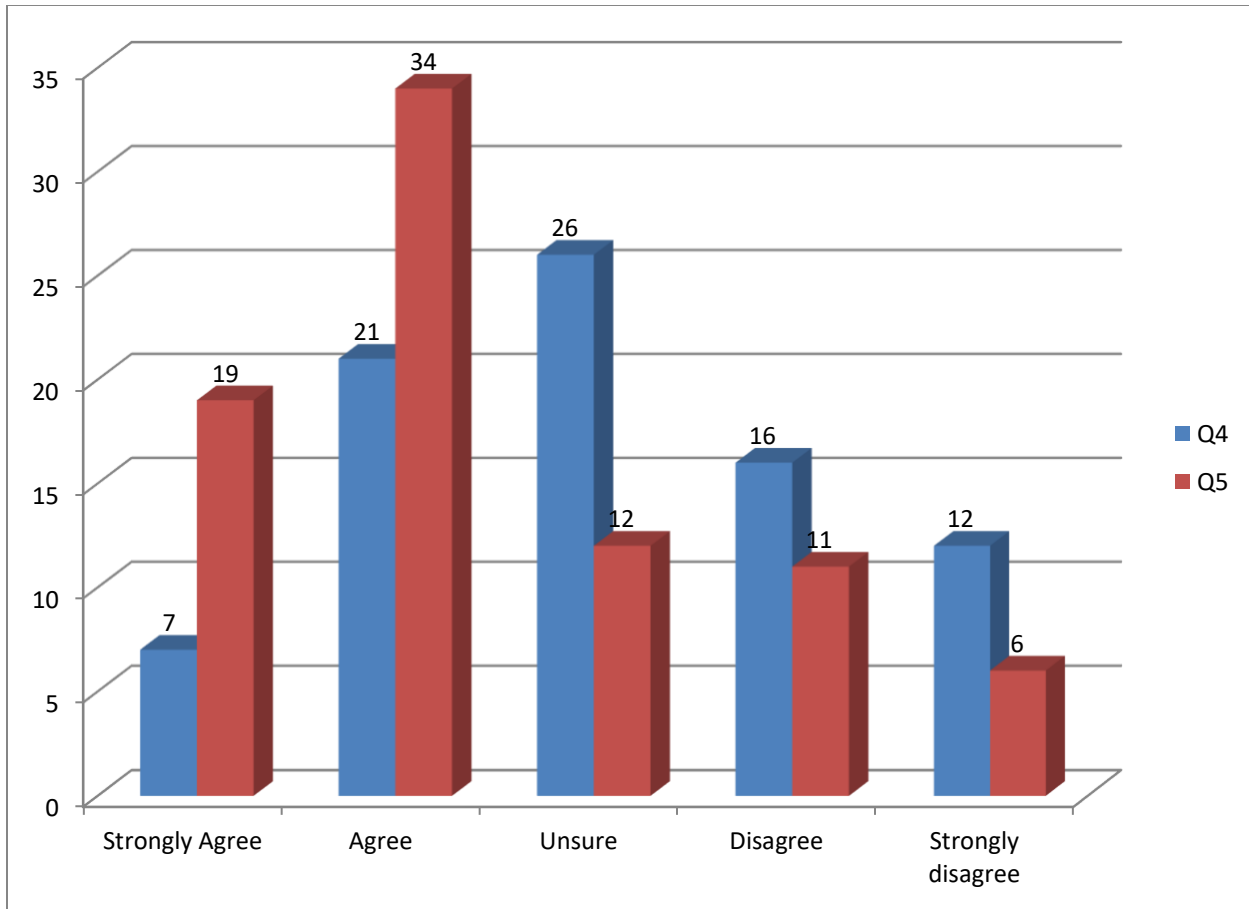


Figure 3

Questions seven and eight sought to determine the extent to which students enjoyed guest speakers in both previous and current science classes (Figure 4). There was a minimal positive increase, but overall the data indicates that the majority of students enjoy guest speakers. All guest speakers in my classes this year were professors with the exception of a physician's assistant. This indicates that students value scientific experts as part of the curriculum. In future classes I plan to poll students at the beginning of the year in order to determine what types of scientific experts they would most like to hear from.

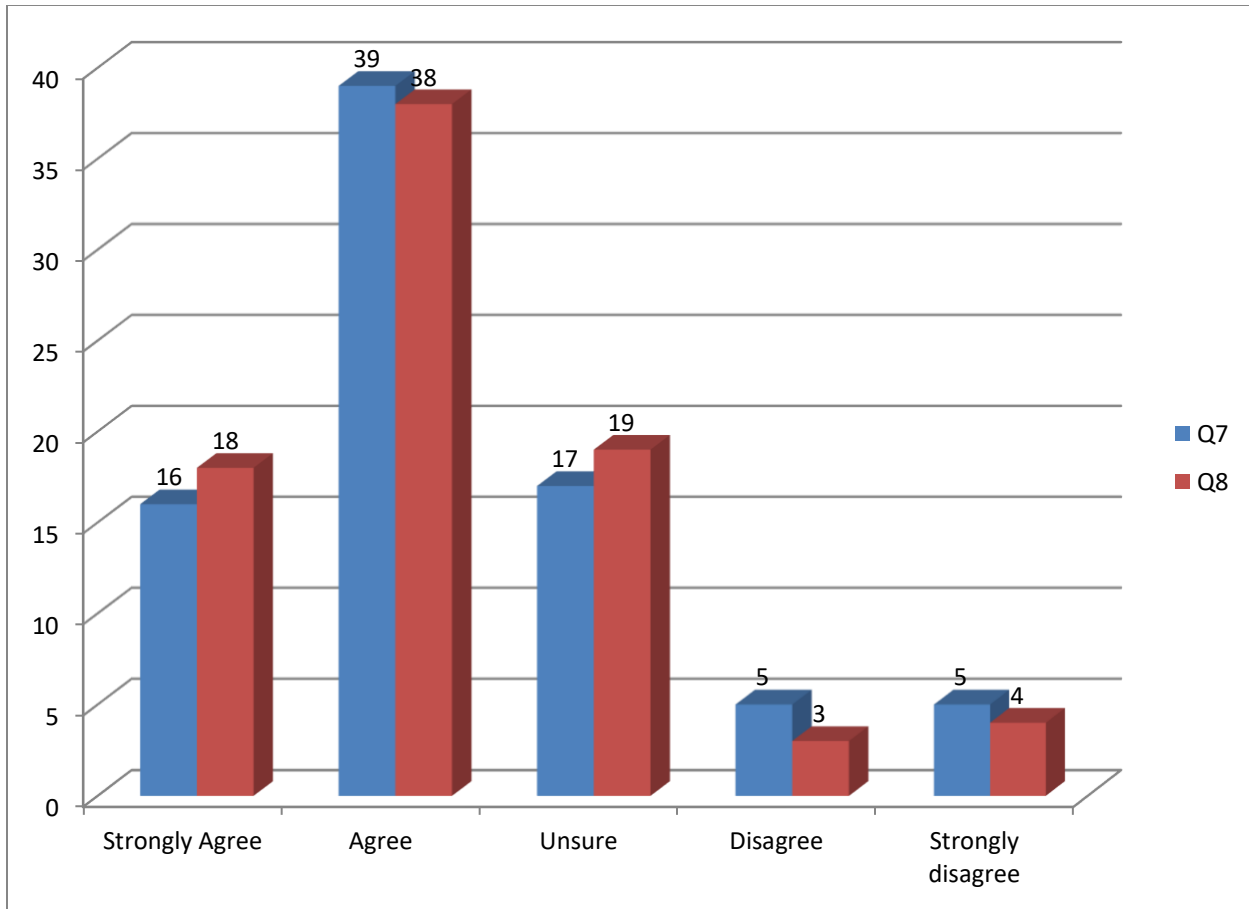


Figure 4

Questions nine and ten sought to measure the extent to which students enjoyed laboratories in Biology Honors as compared to other science classes (Figure 5). Although the survey indicates that the majority of students enjoy laboratories, there was a negative trend when comparing prior experiences to the post data. I attribute this to the fact that the majority of students were enrolled in Physical Science Honors during the previous school year. Having taught Physical Science Honors for four years I know that it consists of short lectures and a multitude of stimulating laboratories that involve dramatic physical and chemical changes. Many of the laboratories in Biology are mild if not tedious by comparison, and require a deeper understanding. Hence, efforts should be made to introduce mild experiments with dramatic demonstrations that link prior experience in Physical Science Honors to current experiments, or when possible use experiments with more dramatic effects.

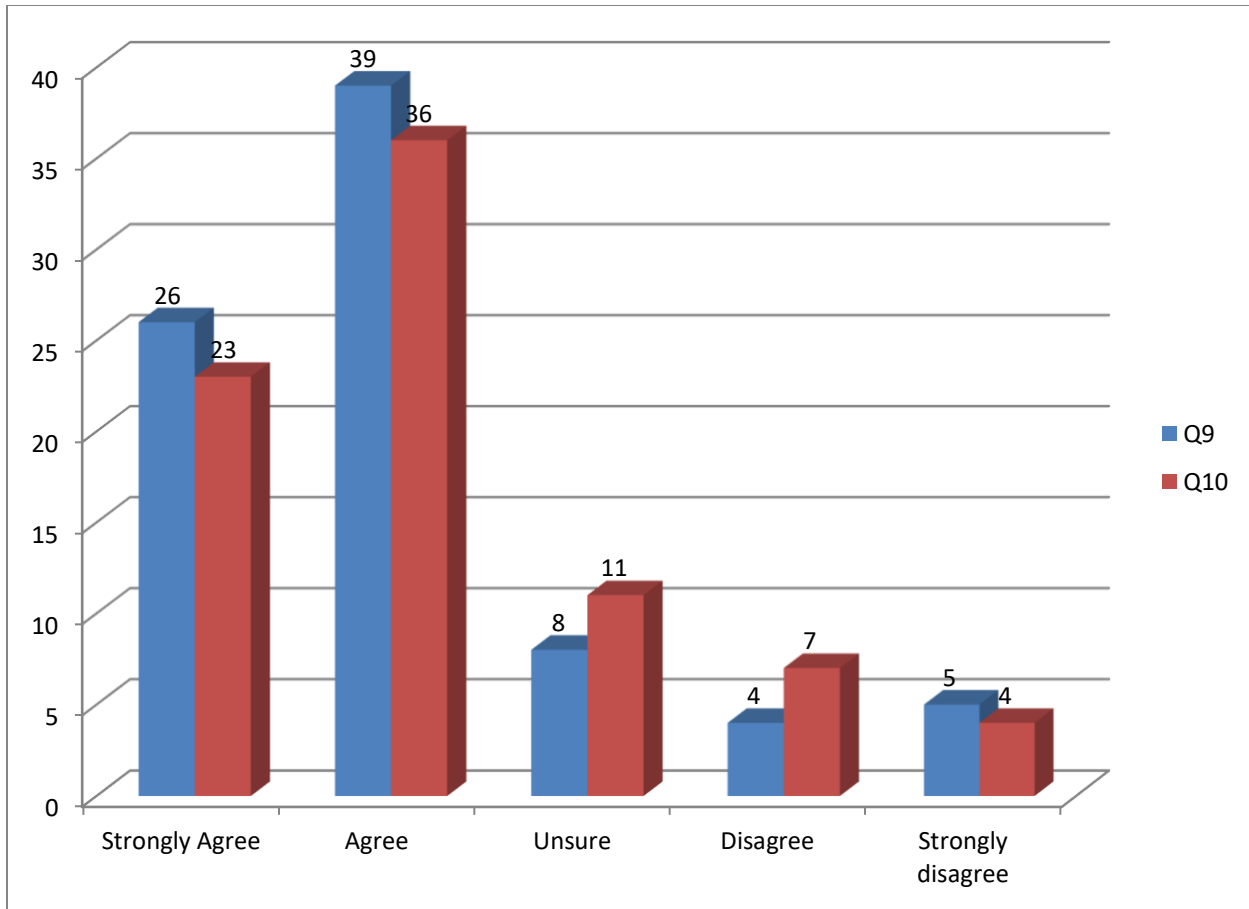


Figure 5

Questions 11 and 12 sought to discover the extent to which students enjoyed using case studies in the curriculum (Figure 6). Although there were more positive responses to these items the responses indicated that there was much indecision and both positive and negative changes in attitude toward case studies. It is interesting to note that in Figure 7, question 16 students indicated that case studies were valuable learning tools. My conclusion here is that although students did not overwhelmingly enjoy case studies, they did recognize that these exercises helped them to learn key concepts in Biology. During discussions students indicated that they thought many of the readings were too long for “bellwork”, therefore making them less enjoyable. I plan to continue using case studies for Biology Honors, but I will limit the length of the reading when using them for “bellwork”. Longer articles will be used for classroom discussion during the lecture.

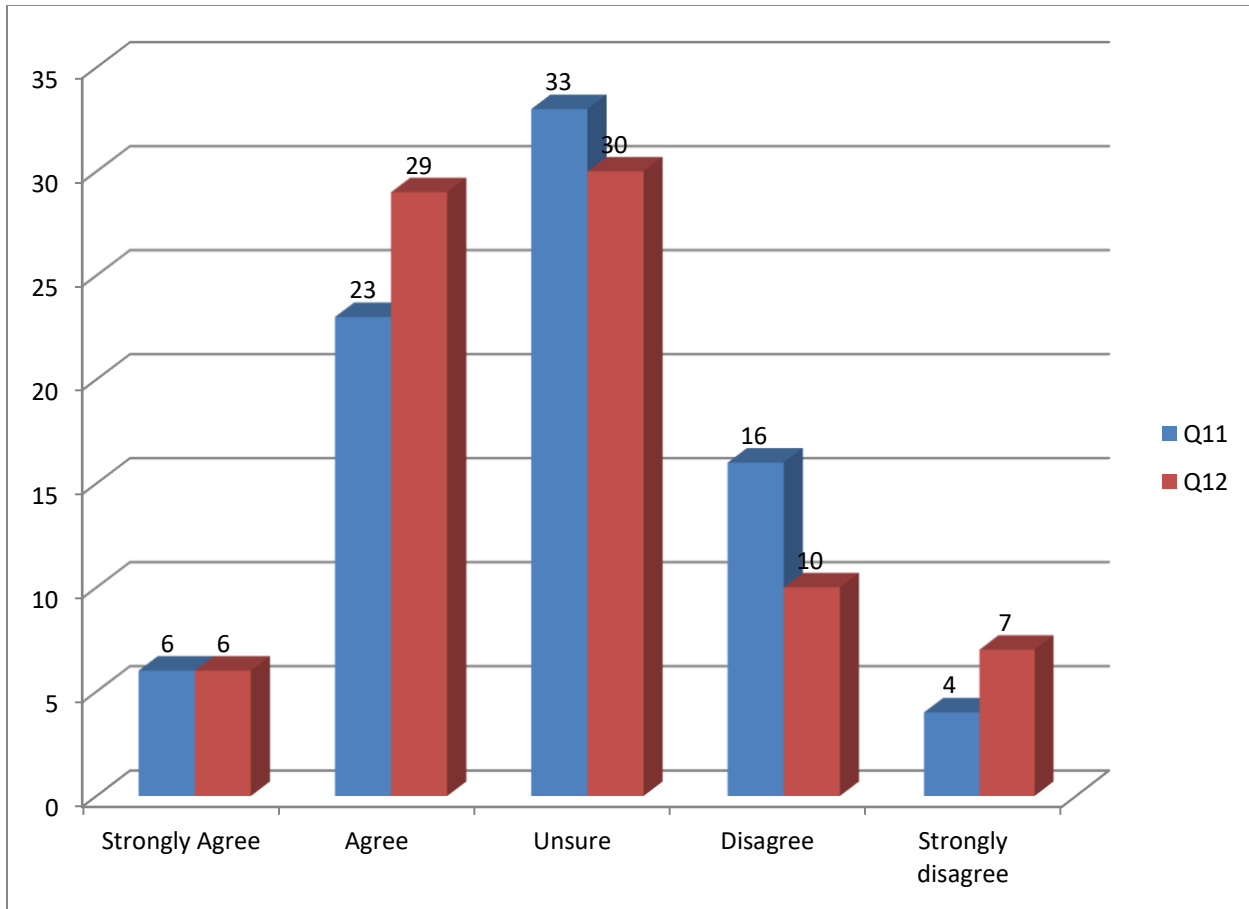


Figure 6

Questions 13-17 sought to measure the ways in which students perceived various elements of the course (Figure 7). Question 13 sought to measure overall student attitudes about Biology. The majority of students had positive attitudes about Biology. This was interesting given the results found on Figures 1 & 2, where the majority of students indicated a lower interest in science and studying science in college. When asked, most students indicated that although they do not think science is necessarily a subject they enjoy or want to study, the class itself was enjoyable.

Questions 14 and 15 sought to measure overall student attitudes and learning experiences surrounding the laboratories conducted by the University of Florida CPET staff. Both of these questions

had a majority of positive responses indicating that students both enjoyed and learned from the presentations of laboratories through UF. Because of this feedback I will continue to foster relationships with Universities and invite them into my classroom for laboratories whenever possible.

Finally Question 17 garnered the most positive responses of the survey questions. This question sought to measure the impact that GIZMOS had on learning. This positive result is to be expected when one considers that the most enjoyable activity for students was found to be the GIZMOS (Figure 3). This would indicate that GIZMOS and computer simulations that are similar have the most potential to transform the classroom environment in science classrooms.

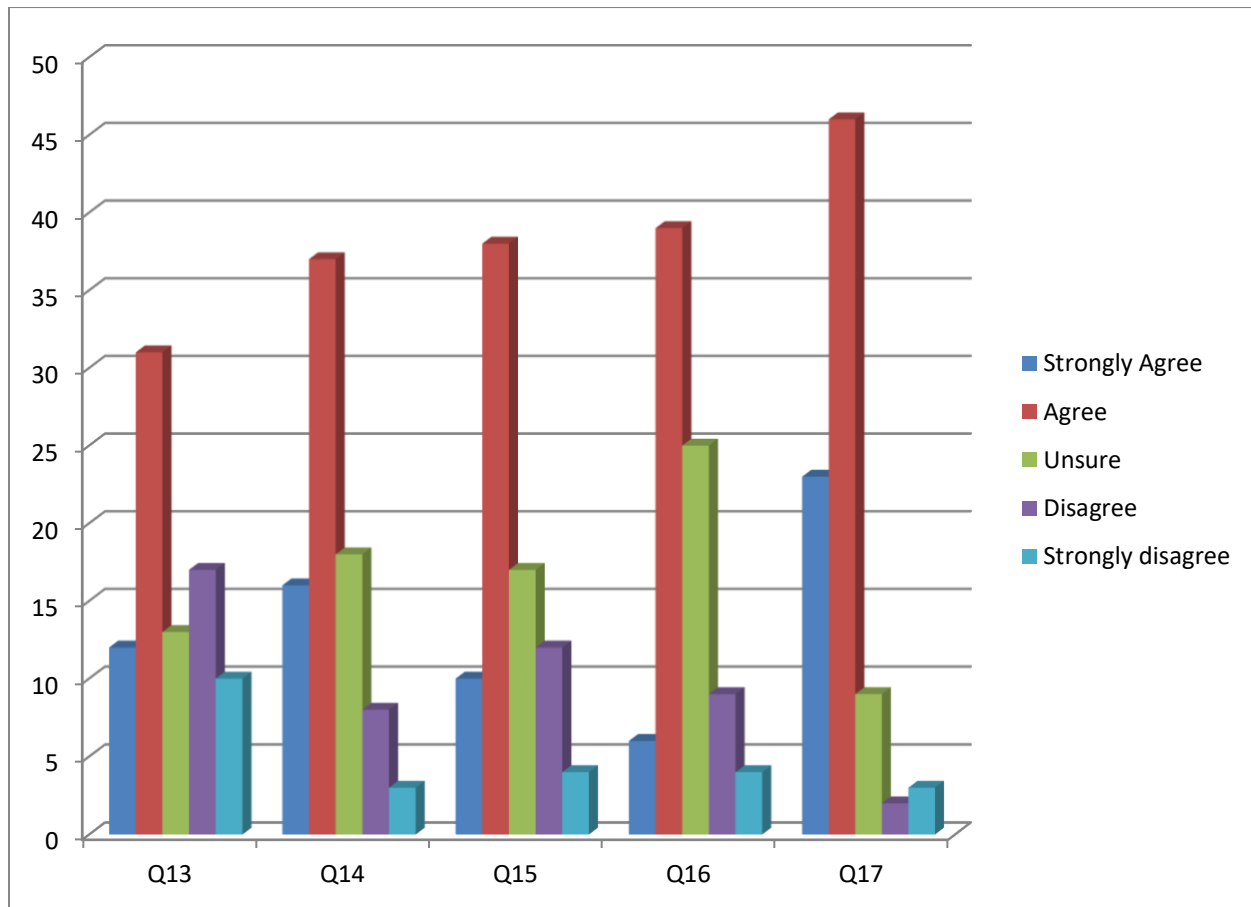


Figure 7

The final component of this project was a trip to UF with five students to present research at JSEHS. This was an invaluable experience and all participants expressed the desire to participate in this symposium next year. The students particularly enjoyed the laboratory visits and meeting representatives from the university. I have also had many students who did not participate in this year's symposium request to be included in next year's trip. Parents also indicated that they valued this experience for their children.

In conclusion the results of this project yielded valuable results for my classroom practice. Clearly online laboratory simulations are the preferred way to improve attitudes and affect student learning in Biology Honors classrooms. However, this method has limitations that are often outside of the teacher's sphere of influence. Nevertheless it is critical that teachers understand the importance of utilizing technology in the sciences, and lobby school districts for resources. Laboratories, university professors, and other scientific experts all provide clear connections to the real world that is important to student understanding and engagement in science courses. Case studies help to solidify this connection and allow students to create their own knowledge concerning real world issues. Participating in scientific symposiums that require students to conduct research provides skills and exposure to new concepts that are invaluable to students. In the coming school year I will implement the aforementioned changes and attempt to hone my pedagogical skills in order to yield more positive attitudes and thus higher learning gains for all students.

Budget and Budget Justification

The only costs for implementation of this program were associated with students attending JSEHS, which included fees of 200.00 dollars each plus 50.00 spending money. Transportation was

provided by private vehicles. Students were responsible for obtaining funding for this experience, in one case a grant was written for a student showing financial need.

Permissions

Parent, science department, steering committee, principal, area director, and school board approval was required and obtained for the JSEHS portion of this project.

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Appendix I

That Horseshoe Crab must really Love you ...

it gave it's blood to save your life. Did you know that a horseshoe crab has probably saved your life?

It's true.....

[Horseshoe crab blood used to test drugs and implants](#)

Horseshoe crab blood is used to test drugs and implants for endotoxins. Endotoxins are byproducts of bacteria that remain even after sterilization. Endotoxins, if injected into the blood stream can cause fever, coma and possibly death.

A horseshoe crab has blue blood which is copper based instead of iron based like our blood (that's why it's blue instead of red). This blood has another unique quality, [horseshoe crabs](#) blood will gel when it comes in contact with bacteria or endotoxins.

This action is part of the [horseshoe crabs](#) primitive immune system. If a horseshoe crab sustains an injury such as a cut, when bacteria tries to enter it's body, it's blood jells which creates a barrier against the bacteria.

Biomedical companies have found a way to extract the compound that makes their blood jell from amebocytes (the only blood cell present) in the horseshoe crab's hemolymph.

This preparation is called Limulus Amebocyte Lysate (LAL). LAL is used to detect endotoxins associated with gram-negative bacteria. These pathogenic bacteria can illicit a pyrogenic response if introduced into the human blood stream, which involves fever, coma or even death.

LAL is used by pharmaceutical and medical industries to ensure that their products (e.g., intravenous drugs, vaccines, and implantable medical and dental devices) have no bacterial contamination. They take a sample and introduce the LAL. If it jells they know that batch is contaminated and must be disposed of.

This is currently the most effective way to test for gram negative endotoxins.

[Horseshoe Crab blood saves our lives again and again](#)

So if you have ever had a tetanus shot, a flu shot or any kind of shot a horseshoe crab has made it possible without you getting sick or possibly dying. So when you get your next shot, thank a horseshoe crab that helped to make sure that it was safe.

[The Horseshoe Crab Controversy](#)

Biomedical Companies need a large supply of horseshoe crabs in order to extract their blood. Luckily they don't have to kill the horseshoe crabs What they do is they harvest the horseshoe crabs and then only extract about 1/3 of it's blood and then they release the horseshoe crabs back into the wild.

It is estimated that it takes about 30 days for the horseshoe crab to replace the blood that was extracted. The biomedical companies report that the process of bleeding causes a 10% mortality rate, but that rate could be much higher.

The Problem lies with the fact that fishermen also need horseshoe crabs for bait when they fish for conch and their use of large numbers of horseshoe crabs started to deplete the horseshoe crab populations. The legislators have put a limit on how many horseshoe crabs that can be taken and now it seems that the horseshoe crab population is on the rebound.

The fishing industry is now pushing for a lift on the limit that they can take for bait . We'll just have to see where this all ends, but it is for certain that it is everybodys interest that there be a healthy horseshoe crab population in the wild.



What is LAL? What does it do?

How do horseshoe crabs help us?

How do you think we should manage the horseshoe crabs?

Appendix II
Survey 'Student Engagement Survey'

1. Prior to Biology I Honors science was my favorite subject.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

2. After taking Biology I Honors science is my favorite subject.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

3. Prior to taking Biology I Honors I was sure that I wanted to study science in college.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

4. After taking Biology I Honors I am sure that I want to study science in college.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

5. Prior to taking Biology I Honors I enjoyed the online simulations (example: Gizmos) that science classes offered.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

6. After taking Biology I Honors I enjoyed the online simulations (examples Gizmos) that were offered.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

7. Prior to taking Biology I Honors I enjoyed learning from the guest speakers that visited my science classes.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

8. After taking Biology I Honors I enjoyed learning from the guest speakers that visited our classroom.

- strongly agree
- agree
- unsure

- disagree
- strongly disagree

9. Prior to Biology I Honors I enjoyed the laboratories presented in my science classes.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

10. After taking Biology I Honors I have enjoyed the laboratories we conducted (example: frog lab).

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

11. Prior to taking Biology I Honors I enjoyed learning through case studies.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

12. After taking Biology I Honors I enjoyed learning through case studies.

- strongly agree
- agree
- unsure

- disagree
- strongly disagree

13. My attitude toward science has improved since taking Biology I Honors.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

14. The laboratories presented through the University of Florida were enjoyable.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

15. The laboratories presented through the University of Florida helped me to understand key concepts.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree

16. The case studies presented in Biology I Honors helped me to learn key concepts.

- strongly agree
- agree
- unsure

- disagree
- strongly disagree

17. Gizmos helped me to understand key concepts in Biology I Honors.

- strongly agree
- agree
- unsure
- disagree
- strongly disagree