Does Pedagogy Really Make a Difference in Improving Learning and Attitudes in a General Education Biology Course?

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Abstract

The purpose of this study was to determine the impact of selected pedagogies (service learning, concept mapping and guest lectures) on student attitude and learning gains in a general education biology class. Two classes, one with the three pedagogies, and one without, were compared. Data were collected from two classes in Fall 2008 (one treatment and one control) and two similar classes replicated in Fall 2009. Learning and attitude gains were measured by a pre and post biology assessment and the Student Assessment of Learning Gains (SALG) survey. Our findings indicate that the treatment methods did not improve student learning or attitudes compared to the control group. However, there was a significant increase in variability in the treatment group, indicating that the students exposed to the three pedagogies either had a very positive experience or a negative one, whereas the control group did not have this variability. Thus, the treatment did have a positive effect on some students. Composite ACT scores also had a significantly positive impact on increases in student learning. Both treatments experienced significant gains from pre to post on the biology assessment and the SALG survey.

Introduction

In the past, the goal of science education was to produce more scientists. While it is still a goal to generate bright, innovative scientists, society recognizes the importance for all citizens to be scientifically literate as more national and international political and societal concerns involve scientific issues (Maehr & Widen, 2002, McDonald & Dominquez, 2005). The National Science Education Standards (NSES) defines science literacy as understanding key concepts of natural sciences, understanding the nature of science, and developing inquiry skills such as designing experiments, collecting and analyzing data, and drawing valid conclusions for evidence (McDonald & Dominquez, 2005).

Despite the need for scientifically literate citizens, there has been a decline in interest in the sciences since the 1970's (Markow & Lonning 1998). Science education is often viewed by students as teacher-centered, based on rote memorization, and focused on test scores (Heinze-Fry & Novak, 1990; Mason, 1992; Huai, 1997; Kinchin, 2001). Because of this, many students view science as a boring list of disconnected concepts, which consequently decreases their desire to learn science (Mason, 1992).

Many approaches have been and continue to be used to help students connect their learning and become actively involved in the learning process. One such approach is service learning. Multiple studies have analyzed the effects of service learning on student learning and engagement among all levels of education (Strange, 2004, Astin & Sax, 1998, Brindle & Hatcher, 1996, Mcdonald & Dominquez, 2005, Kronick, 2007). Research demonstrates that simply having knowledge of an issue does not result in behavioral change. Students must feel a responsibility for their environment and take ownership over issues (Mcdonald & Dominquez, 2005). Service learning may be one vehicle to provide an opportunity for students to take responsibility.

Although service learning can be implemented in a variety of ways, the Commission of National and Community Service (CNCS) has defined what service learning should entail in order to be used as a vehicle to help students in the learning process. The CNCS states that service learning is active participation in organized service experiences that meet community needs. These service experiences should integrate the students' academic curriculum. They should include time to think, write and reflect on their service experiences and allow students to use newly acquired skills and knowledge in real-life situations (Mcdonald & Dominquez, 2005). Eyler & Giles (2002) defined service learning as being "about doing, about action, about learning from experience, and using the knowledge and skills in learning…about knowledge in use, not just about acquiring and being tested on facts" (p.9). Service learning allows students to connect academic knowledge learned in the classroom to issues in their real lives and community, which help them to develop a sense of civic responsibility (Mcdonald & Dominquez, 2005). In other words, they begin to see that what they learn in the classroom actually applies to real-life situations.

Guest lectures may also be an effective pedagogy to help students connect the material they learn in the classroom, although few studies have analyzed its effects. In one study conducted by Maehr & Widen (2007), the benefits of international guest lectures were explored. The study focused on an international conservation biology course using international guest lectures to expand viewpoints and develop a better understanding for international conservation issues. The study demonstrated an improved cultural and political understanding in issues related to the countries involved in the guest lectures (Maehr & Widen, 2002). Another study conducted by Hemphill & Hemphill (2007) explored online guest lectures, which was found to enhance critical thinking skills and interest levels in the students (Hemphill & Hemphill, 2007). The benefits from these online guest lecture studies may be applied to other forms of guest lectures, although it has not yet been investigated.

Concept mapping is another method used to help students make connections with their learning and to help students see the "big picture". It is designed to aid students in connecting the concepts to each other

and also to the students' own experiences. Concept mapping is often used as a classroom instruction tool in the form of visual aids (Horton *et. al.,* 1993), as well as tools for more student involvement where students actually are involved in concept mapping activities (Regis *et al*., 1996). Student responses to concept mapping are varied; some believe that it helps them to identify, organize and retain information while others feel that is not helpful (Heinze-Fry & Novak, 1990). Although there are mixed opinions as to whether or not it is worth it to use concept mapping given the preparation and training time, concept mapping can help move both teachers and students to instruct, to assess, and to learn deeply (Briscoe & LaMaster, 1991).

Our study was designed to investigate ways to help students succeed and enjoy introductory level biology courses. This study was unique in that it tested the effects of three different teaching pedagogies on students learning and attitude gains in an introductory college biology course. Previous studies have focused on analyzing the effects on each pedagogical technique independently; we have used the combination of these three techniques in our classes for over ten years and wanted to test the combined effects of these pedagogies on student achievement. These methods are: Service learning, guest lectures and concept mapping.

Research Hypotheses

Freshman Biology students who experience an "enriched" environment consisting of service learning, concept mapping, and guest lectures, will have a greater understanding of biological concepts, as well as an increase in their perception of understanding, skills, and attitudes toward biology over the course of the semester. More specifically, the mean increase from pre- to post-course scores for the enriched-environment freshman biology class (treatment) will be significantly greater than the mean increase from pre- to post-course scores for the non-enriched class (control) on both the biology assessment and the Student Assessment of Learning Gains (SALG) survey.

The Sample

Freshman Academy

The students in this study came from an organization called Freshman Academy, as part of Brigham Young University. Freshman Academy is designed to help incoming freshman adjust and connect to the university learning environment. The incoming freshmen that choose to participate in Freshman Academy choose an envelope of three classes, which they will take together. Freshman Academy students live in close proximity of each other and have peer mentors and professors that should aid them in their adjustment to college.

The biology classes formed from the entering freshman class of Fall 2008 were examined for equality in gender ratios, entering high school GPA, and entering ACT scores (Table 1). The 2009 biology classes were also examined (Table 2).

There were fewer students in the second year of the study because fewer students registered for Freshman Academy envelopes in 2009, due to a registration problem. The differences in ACT and GPA scores between the students in both Fall 2008 and Fall 2009 were adjusted for in the regression analysis. Although there were some differences, similarities between 2008 and 2009 classes were greater than what is usually expected in such studies, partly because all students were part of Freshman Academy.

Methods

A comparison study between two biology classes was used to evaluate the effects of an enriched learning environment on student achievement, content knowledge and attitudes.

The Control

Both classes of Biology 100 were within Freshman Academy, and shared the elements unique to the Freshman Academy program. Measures were taken to ensure that other elements of these classes were consistent. There were several components to Biology 100 that were incorporated in both the control and treatment classes in this study:

Instruction. The same instructor, Dr. Gary M. Booth, taught both Biology 100 classes. In Fall 2008, the treatment class was held at 12pm MWF and the control class was at 1pm MWF. In Fall 2009, we switched it so that the control class was taught first at 1pm MWF and the treatment class was taught at 2pm MWF; each class period was 50 minutes long. Professor Booth has been teaching for 36 years and has developed his own unique style of teaching, which he tried to keep identical for both the treatment and control classes. To help ensure this consistency, we switched the order of treatments during the second year.

Teaching assistants and labs. Each class was divided into four lab sections (30 students in each for Fall 2008 and approximately 15 students in each lab for Fall 2009); these labs met for 50 minutes once a week. Trained teaching assistants taught the labs; two TA's were assigned to each lab section. One TA was responsible for teaching and the other TA was responsible for grading.

Instrumentation.

Students also took four exams throughout the semester in both classes. The objective portion of the test was identical for both classes. Each test consisted of approximately 90 to 100 multiple choice questions. The control class also completed one to two essay questions and the treatment class completed one to two concept maps. The content for the essays and concept maps was the same and same number of points were allotted (20 points).

Students in both classes also took a pre and post biology assessment and pre and post Student Assessment of Learning Gains (SALG) survey, which are described in the measures section.

Peer Mentors. As both classes were within Freshmen Academy, both had peer mentors to aid the students in time management and in organizing study groups.

Research paper. Each student in both classes was required to write a six to eight-page research paper on a topic related to any biological concept discussed in this course.

Homework. The homework assignments for the two classes were different, but the time required for the assignments was approximately equal and the points allotted were the same. The treatment class' assignments consisted of approximately one concept mapping a week, eight hours total of service learning (including a reflection paper due at the end of the semester) and two required guest lectures. The students in the control class were required to submit two write-ups each week on current events that related to science.

The Treatment

The treatment classes in 2008 and 2009 participated in the following pedagogical activities:

Concept Mapping. Concept mapping was implemented in the treatment class through weekly labs and concept mapping assignments.

Six concept maps were required of the students each month. We began with concept maps that only required the students to fill in missing links (skeletal maps). Later, we trained the students on how to create their own concept maps when given a list of concepts (self-construction).

Service Learning. The different projects for Fall 2008 were: Senior World Games, Adaptive Aquatics, Bean Museum Tours, and Science Education in Elementary Schools, a June suckers project at Utah Lake and a potato project in Idaho:

Senior World Games. Dr. Gary M. Booth took a group of 15 students to St. George, Utah to volunteer at the Senior World Games. The students helped with registration and measured the heart rate, blood pressure, blood-glucose levels, bone density, glaucoma, and other health related tests for the

participants. They volunteered for two days and learned much about gerontology, disease, and the human body.

Bean Museum Tours. This lab group volunteered at the BYU Bean museum, which has live reptile shows and a huge exhibit of stuffed animals. The volunteers led tours through the museum and aided in the reptile shows. These students were able to gain greater knowledge of animals and their ecosystems.

Science Education in Elementary Schools. Biology students worked with an elementary classroom teaching the children four lessons on basic biology principles. Students learned the biology principles by teaching and designing projects that helped students learn the concepts.

June sucker project at Utah Lake. One lab group (approximately 30 students) went to Utah Lake with Dr. Mark Belk (BYU professor) to aid in a project to study the June suckers in Utah Lake. The students went out on boats and collected crates of fish. They then counted the suckers and measured their sizes so that the population of June suckers could be marked. Dr. Belk spoke with these students about the importance of this ecosystem.

Potato project in Idaho. Approximately 15 students went to Idaho with Dr. Brian Hopkins (BYU professor) to work on a project to help improve potato production. The students picked and measured potatoes on the farm lot used for this study. The students learned about world hunger issues and how genetically engineered products can help feed a growing world population.

The following were the service learning projects for Fall 2009: Senior World Games and Adaptive Aquatics.

The Senior World Games requested more volunteers this year, so we sent three of the four labs in the treatment class to the Senior World Games. They performed the same volunteer services as the previous year.

Adaptive Aquatics is a BYU-student operated organization set up for children with disabilities to come swim and play sports with BYU student volunteers. Students were able to see the effects of genetic disorders and experience first-hand how genetics can influence lives.

Guest Lectures. The Professors and specialists from BYU and the community spoke to the students about concepts learned in class that related to their specific fields of study. Focus was placed on allowing students to see how the concepts they learned in class were applied to professions and research around the world.

In Fall 2008, four guest lectures were available for the students over the course of the semester, averaging one lecture per month. Guest lectures were held outside of class, usually in the evenings. Two lectures were required, and students received extra credit for attending the other two lectures. For the first year's study the following guest lecturers spoke:

Sean Esplin, M.D. Dr. Esplin is a neonatologist who works in Salt Lake County. He spoke to the students about human development and genetic disorders.

Byron Adams, PhD. Dr. Adams is a faculty member of BYU in the Department of Biology. He discussed his field research in Antarctica relating to global warming and evolutionary change and discussed how the Central Dogma (DNA replication, transcription and translation) is important in his research.

Clayton White, PhD. Dr. White is a faculty member of BYU in the Department of Plant and Wildlife Sciences. He discussed his research with a variety of birds of prey, particularly the Peregrine Falcon and the impact of DDT.

Ron Hager, PhD. Dr. Hager is a faculty member of BYU in the Department of Exercise Science. He spoke about the effects of healthy lifestyle and diet on the human body.

We provided two mandatory guest lectures for the second year (Fall 2009): *Dr. Sean Esplin* and *Dr. Byron Adams*. Both lecturers gave the same seminars as described above. Because of the low number of students in our classes the second year, we did not provide the two optional guest lectures. Instead, students could attend any two science/biology related lectures offered by the College of Life Sciences.

Measures

Student Assessment of Learning Gains (SALG). This survey was constructed by the NSF-funded program, *Science Education for New Civic Engagements and Responsibilities (SENCER).* SENCER aims to help teachers direct undergraduate students in applying math and sciences to become engaged and responsible citizens. SENCER developed the SALG survey to help teachers measure learning gains in their classrooms. The SALG survey is divided into four main sections: Understanding Gains, Skill Gains, Attitude Gains, and Integration of Learning Gains. Although we observed the scores in all four sections, we were most interested in the attitudes section.

The SALG pre-survey was available to the students online during the first week of school so the students would complete the survey before being influenced by the lectures or coursework for Biology 100. The students took the post survey the last week of class. We closed the survey before the students took the final exam so as to avoid any skewed survey results due to any anxiety or other feelings associated with taking the final exam.

Biology Exam. Professor Gary M. Booth and his graduate students constructed a biology examination to test students on the main concepts taught in this Biology 100 course. Dr. Booth has used this survey for over ten years and only small alterations were made to ensure that the exam was an accurate representation of the intended learning outcomes of the class. The students took the biology (pre) exam the first Friday in class before significant instruction was given. The same biology (post) exam was given the last week of class instruction in the labs. TAs graded both pre and post exams.

Statistical Analysis

The data were analyzed using a mixed model multiple regression analysis to compare the effects of the treatments on pre and post scores on both the biology exam and the SALG survey (understanding, attitudes, skills, integration of learning). The effects of ACT scores, gender, GPA, and declared science majors were included in the model. Significance was $\alpha \leq 0.05$.

Biology 100 control and treatment (enriched) classes

First Year

Pre and post-score assessment

There were no significant differences between the control and treatment groups ($p=0.6888$). The control class scored higher on both the pre and post assessment, but the increase from pre to post was no different for both groups. However, both groups significantly improved from pre to post ($p<0.0001$; Figure 1).

ACT math scores had a significant impact on assessment scores ($p=0.0305$); i.e., students with higher ACT scores had significantly greater increases in their pre to post scores.

SALG understanding

The change from pre and post scores for the two groups was not significantly different on the understanding section of the SALG ($p= 0.6270$). But again, ACT composite score was the only indicator that showed significance ($p=0.0004$); students with higher ACT composite scores, on average, had a greater increase between pre and post scores in the understanding section. Additionally, both classes significantly increased from pre to post ($p<0.0001$; Figure 2).

SALG attitude

There was a significant difference between the control and treatment class in attitude gains from pre to post ($p=0.0374$). However, it was the control class that had greater gains (with an average increase of 0.7633) than the treatment class (with an average increase of 0.5697).

ACT composite scores also had a positive impact on attitude gains ($p=0.0018$; Figure 3) and students that were science majors had significant increases from pre to post in comparison to non-majors ($p<0.0001$).

SALG skill

As shown in Figure 4, there was a significant difference between the control and treatment class from skill pre to post scores, with the control class having the greatest skill gains (p=0.0238).

ACT composite again significantly contributed to skill gains, with higher ACT composite scores having higher skills gains (p=0.0048). Both classes significantly increased their skills from pre to post (p<0.0001).

SALG integration of learning

When comparing student desire to integrate what they learned in class with other aspects of their lives, there was no significant difference between the two classes (p=0.6463). The only variable that had a significant impact on changes between the pre and post scores was again the ACT composite; i.e., those that had higher ACT composite scores tended to have greater increases from pre to post (p=0.0016). There was a highly significant increase (p<0.0001, Figure 5) in both classes from pre to post.

Second Year Results

For the second year, we decided to only use ACT composite as an indicator rather than using the subdivisions of the ACT test: math and English. These latter two indicators had so much overlap that we felt the composite adequately represented the effects of ACT on student results.

Final Exam

Pre and post assessment

After adjusting for the important predictors such as ACT scores and GPA, the combinations of pedagogies did not make a difference in the average increase in biology assessment scores from pre to post; both classes had about the same increase from pre to post (p=0.7362). The only predictor that had a significant impact was the ACT composite; those having a higher ACT score showed a greater increase from pre to post (p=0.0168). Both classes significantly improved from pre to post (p<0.0001). These results were very similar to the previous year (See Figures 1 and 6).

SALG understanding

Although both classes significantly increased their perception of understanding from pre to post (p<0.0001), there were no significant differences between the two classes (p= 0.7525). High school GPA apparently did have a positive effect on increased understanding from the pre to the post, indicating that those with higher GPAs had greater increases from pre to post (p=0.0612; Figure 7).

SALG attitude

There were no significant differences between the control and treatment groups in relation to attitude gains (p=0.2986). The previous year did have a significant increase in favor of the control group. The control class had significantly higher pre and post scores (p=0.00098) for unexplained reasons, but the increase from pre to post was no different than the treatment class the second year. The only significant indicator was the science major; those students who declared a science major at the beginning of the semester clearly had highly significant attitude gains from pre to post (p=0.0003). Both classes had highly significant increases in attitudes (p<0.0001; Figure 8).

Students in the treatment class displayed a significantly greater increase in variance for the attitude score than students in the control class (p=0.007) with the variance for the pre survey at 0.4541 and the variance for the post survey at 0.7224 for the treatment class. In fact, the control class displayed a decrease in variance with their pre-survey variance being 0.3588 and post survey variance at 0.2940. In other words, random people, not associated with low GPA, gender or any of the other indicators we accounted for, tended to display more of a decrease or more of an increase in their attitude score in the treatment class than in the control class at the end of the semester. The Fall 2008 data showed the same trend for variances, but the

effect was not statistically significant (p=0.141). The significant differences in variation between the two classes were not found in the two sections of the SALG: understanding and skills. Integration of learning had significant differences in 2008, but not in 2009. The integration of learning questions are most closely linked with the attitude section. Hence, these results in variation suggest that the pedagogies may affect attitude gains, but not gains in content knowledge or skill.

SALG skill

There were no significant differences between the control and treatment classes in skill gain (p=0.2922) and none of the other indicators had a significant role in skill gain. Both classes did significantly improve from pre to post (p<0.0001). The control class had a significantly higher pre and post score than the treatment class (p=0.0154) but the increase from pre to post was not significantly different (p=0.2922; Figure 9).

SALG integration of learning

Although both classes increased significantly from pre to post in how well they integrated concepts learned in biology to other aspects of their lives (p<0.0001), there were no significant differences between the two classes (p= 0.2289). The only indicator that approached significance in affecting the increase from pre to post was if the students were a declared science major (p=0.0548; Figure 10); those that were declared science majors had greater increases from pre to post scores.

Discussion

Multiple factors could have contributed to the lack of significant differences between those that were involved in the enriched activities (treatment class) and those that were not (control class) on both the biology pre and post exam and SALG survey.

Small sample size for both the control and treatment classes may have contributed to the results. However, while small sample sizes often lack statistical power, they can still be meaningful and are found in the literature in similar research studies (Reed *et al.* 2005).

Although Freshman Academy helped keep many variables the same between the two classes (i.e., GPA, ACT scores, etc), it also gave the students in both classes opportunities for help that would not typically be available in most general education biology classes. Freshman Academy classes provide a unique environment that steers away from the lecture-oriented, high enrollment courses taught in amphitheater settings that commonly lead to high anxiety and poor attitudes toward science (Mallow 1981). Freshman Academy encourages students to interact with each other, the TAs, peer mentors, and with their professors, whereas the typical college teacher-centered lectures often alienate students from their professors and discourage interaction (Tobias, 1986). The overall benefits of Freshman Academy available to both the control and treatment classes possibly masked the impact of concept mapping, service learning and guest lectures.

The length of the semester and time exposed to the enriched pedagogies may also have affected the results. However, the time needed for these pedagogies to impact students is not clear. For example, many studies have shown significant improvements due to the use of service learning only after months of exposure (Strange, 2004, Astin & Sax, 1998, Brindle & Hatcher, 1996). Indeed, Reed *et al.* (2005) demonstrated positive results after only a one-week exposure to service learning. In the four months the students were enrolled in Biology 100, they had eight hours of service learning, less than 16 weeks to learn and create concept maps, and only four guest lectures. Perhaps more time was needed to see the full impact of the treatment pedagogies.

In addition, most students are accustomed to courses with traditional class instruction and assignments. Some students expressed frustration and impatience in not immediately understanding concept

mapping and found it time consuming. Clearly, there are some students who do not find enriched pedagogies helpful (Heinze-Fry & Novak, 1990). Other students expressed frustrations with attending guest lectures in the evenings. Some of the service learning projects were long and in some cases, personal items such as cell phones were damaged. Some students had difficulty in adjusting to new learning methods and perhaps this frustration masked the potential long-term benefits of using these enriched pedagogies. Again, a longer duration of involvement might enhance the significance of the treatment impacts.

However, despite the lack of significant learning and attitude gains between the two classes, there were some interesting and noteworthy findings. First, these data indicate that there was a possible teacher effect. Both classes improved significantly in all areas over the semester ($p<0.0001$), and an important constant variable in both classes was the teacher. Although further investigation should be conducted to explorer the teacher effect and the role of a teacher's ability to connect to students in relationship to student learning and attitude gains in the sciences, many studies have indicated that a teacher, his/her enthusiasm for the course and the students, and his/her knowledge of the subject matter can have a tremendous influence on student attitudes toward the subject and course (Tobias, 1990; Osborne & Simon, 1996; Turner-Bisset, 1999; Shulman, 1986).

The variation in attitude scores between the control and treatment courses was highly intriguing. The students in the treatment course had significantly greater variability in post-semester attitudes. In other words, those involved in the various pedagogies had a wide variety of reactions to the experience; some student attitudes increased significantly after their experiences with service learning, concept mapping and guest lectures. Other student indicated that they had a negative attitude toward biology after their experiences with these pedagogies. Interestingly, the students in the control class did not display this high variability; the majority of the students in this class ranked themselves about the same as far as their attitudes toward biology post-semester.

It is common for students to exhibit greater variability in attitude post-semester in comparison to early on in the course (Hilton, *et. al.,* 2004); however, the current study is unique in that the treatment class exhibited significantly greater variability ($p=0.007$) than the control. Why do some students have such a positive experience with enriched activities whereas others have a negative experience? This study reveals that the three pedagogies used in the treatment class had a positive effect on select students within the treatment class, but it was not connected to student GPA, ACT, gender or any of the other variables that were under investigation. Previous research suggests that personality differences can have an effect on student achievement (Wagerman & Funder, 2007) especially in the "hard" sciences (Goh & Moore, 1978). Perhaps personality differences contributed to these results and if so, then personality tests could be used to further analyze if specific types of personalities enjoy these enriched activities better than others.

Another interesting pattern found in the results of this study was the effect of ACT scores on student learning and attitude gains. ACT scores were positive indicators for student gains in all areas (biology assessment, understanding, attitude, skills, and integration of learning) during the first year of the study. During the second year, ACT was a positive indicator for the biology assessment score increases. These data are consistent with previous studies indicating that ACT scores are strong indicators of undergraduate college student success (Covington, 1992; Lavin, 1965; Willingham, *et. al*, 1990; Harackiewicz, et. al., 2002). We also saw that GPA was a positive indicator for attitude gains in 2009.

The students that enrolled in this course with a declared science major also showed significantly higher attitude gains ($p<0.0001$ in 2008; $p=0.0003$ in 2009). It is logical that those students who have had positive experiences with science, or have interest in the sciences prior to taking a course will be more likely to enjoy the course overall.

Conclusion

This study demonstrated that pedagogical methods did not play a significant role in student learning and attitude gains for the class as a whole, despite the significance of the individual pedagogical methods in other studies (Blyth *et. al.*, 1997, Reed *et al.* 2005, Hemphill & Hemphill, 2007, Mintzes & Wallace, 1990).

However, the treatment pedagogies did make a significant difference for some students. For example, there was significantly greater variability in attitudes post-semester in the treatment class in comparison to the control class, indicating that enriched pedagogies did have a significant effect for certain students. One hypothesis is that student personality makes a difference in how well the student connects with enriched pedagogies. Hence, these data indicate enriched pedagogies do benefit some students.

In addition, GPA and ACT scores proved to be valuable indicators of student learning and attitude gains, which is consistent with the literature (Rose, 1999). ACT was a positive indicator of gains in all of the areas measured (biology assessment, understanding, attitude, skills, and integration of learning) in 2008 and in one area in 2009 (biology assessment). GPA was a positive indicator of attitude gains in 2009. Those that were declared science majors had significantly greater attitude gains than those who were not in both years of the study.

Students in both classes significantly improved in all areas from pre to post-assessment. Further investigation should analyze the teacher effect, as this was a key consistent variable in both classes. It is possible that the teacher effect masked the possible benefits of enriched pedagogies on student learning and attitude gains. However, it is important to note that enriched activities did not detract from student learning of "core" concepts, which is a concern expressed by educators who question whether enriched pedagogies should be used (Strange, 2004). In short, the enriched pedagogies did not detract from student learning or hurt student learning in any way.

Furthermore, a larger sample size and a longer time frame might be helpful in increasing statistical power and also providing more evidence and valuable insights as to the effects of enriched pedagogies.

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Table 1: Fall 2008 Freshman Academy Biology 100 student statistics

	Treatment Class		**Control Class**	
	Female	Male	Female	Male
	65	53	72	44
Gender	55.08%	44.92%	62.07%	37.93%
HS GPA	3.7268		3.7457	
ACT	26.92		26.01	
Housing	Helaman Halls		Heritage and Wyview Park	

Table 2: Fall 2009 Freshman Academy Biology 100 student statistics

	Treatment Class		**Control Class**	
	Female	Male	Female	Male
	27	20	10	19
Gender	57.45%	42.55%	34.48%	65.52%
HS GPA	3.7368		3.7711	
ACT	27.5745		26.9286	
Housing	Heritage and Wyview Park		Helaman Halls	

Figure 2: Fall 2008 pre and post biology assessment for control and treatment classes: percentage correct

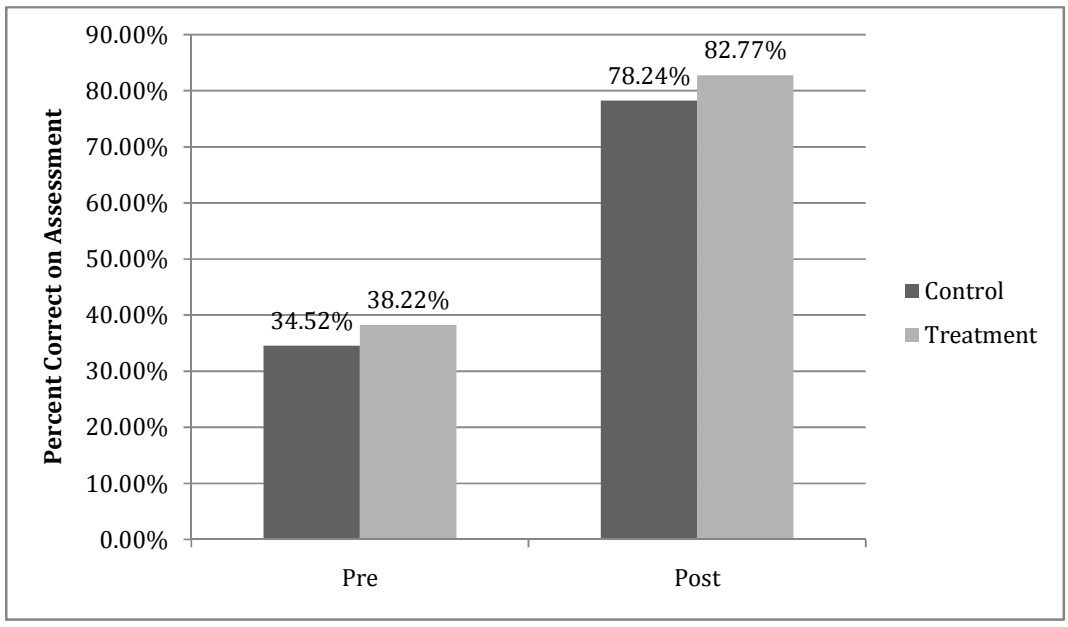

Figure 3: Fall 2008: Comparision of Understanding: Average pre and post scores for control and treatment classes.

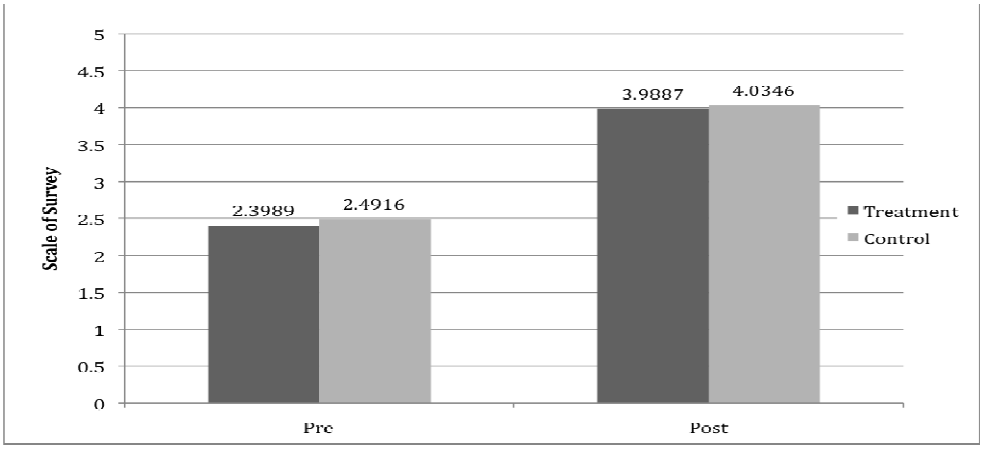

Figure 4: Fall 2008 Comparison of Attitudes: Average pre and post scores for control and treatment classes.

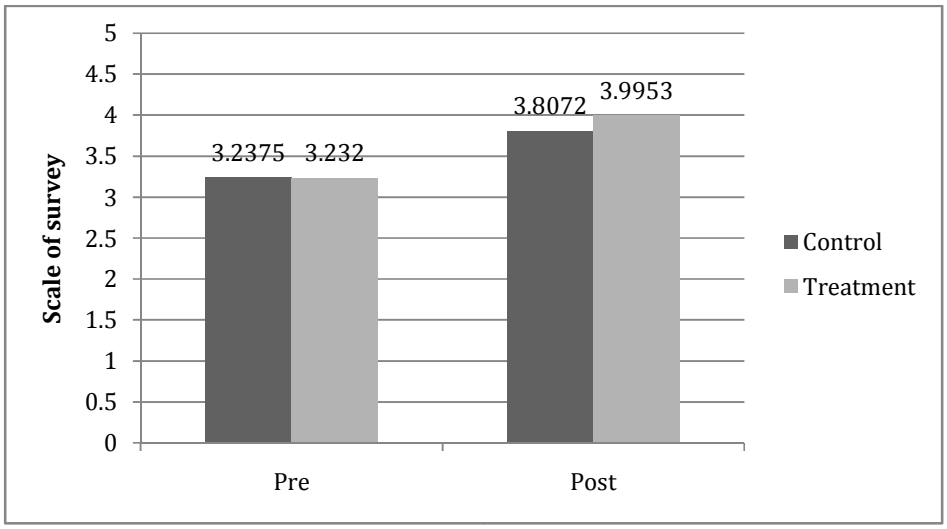

Figure 5: Fall 2008 Comparison of Skills: Average pre and post scores for control and treatment classes.

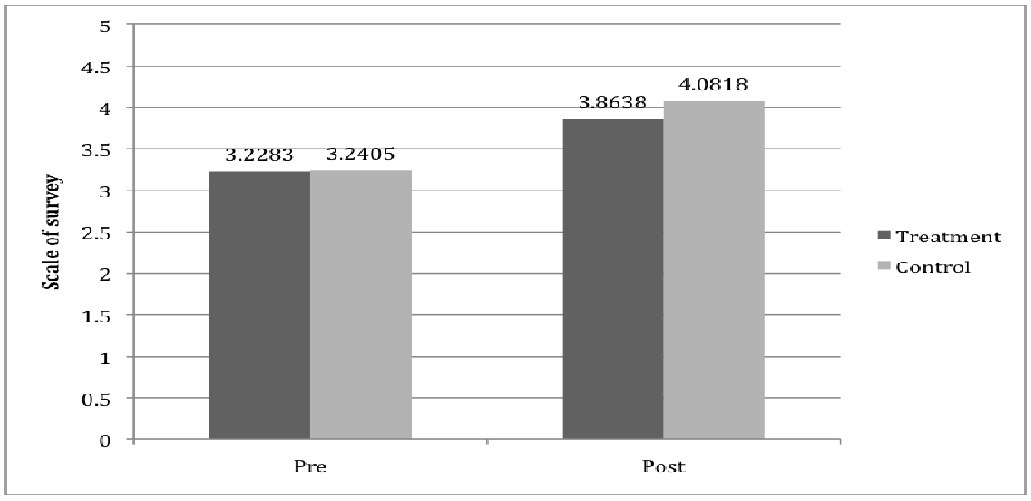

Figure 6: Fall 2008 Comparison of Integration: Average pre and post scores for control and treatment classes.

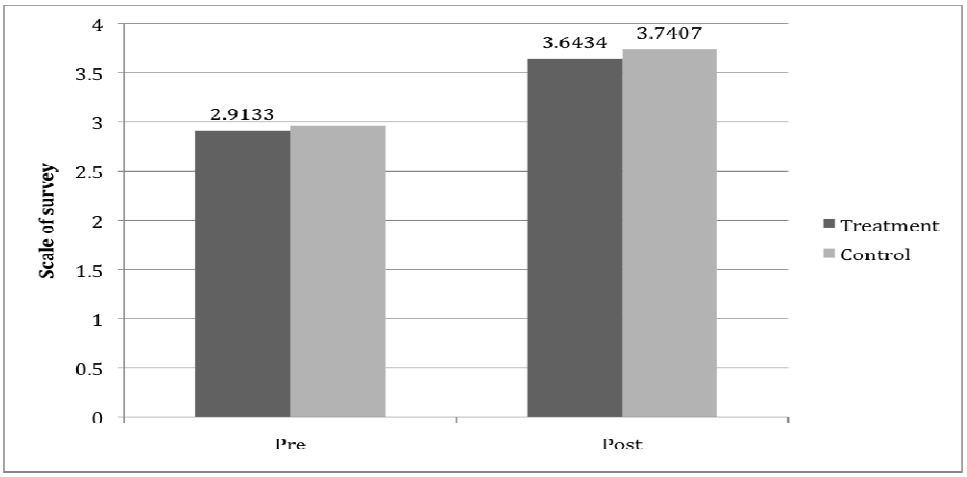

Figure 7: Fall 2009 pre and post biology assessment for control and treatment classes: percentage correct

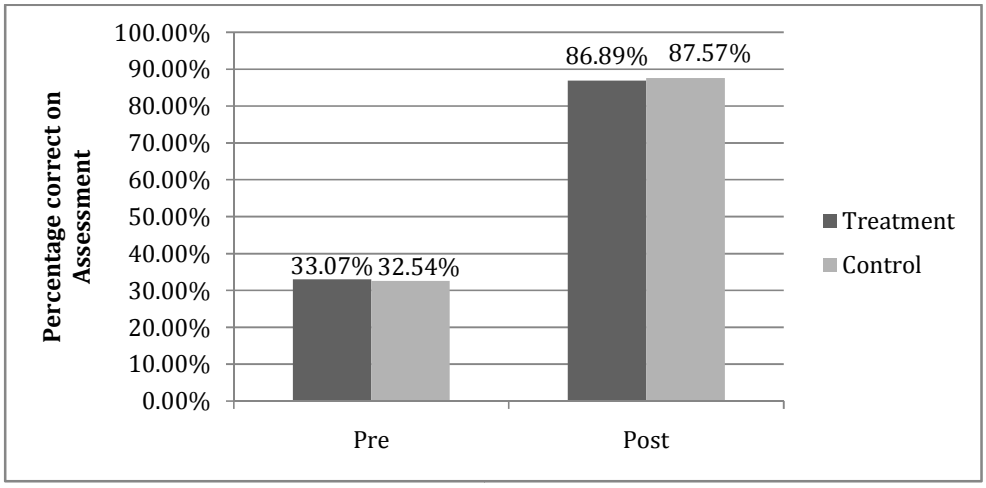

Figure 8: Fall 2009 Comparision of Understanding: Average pre and post scores for control and treatment classes.

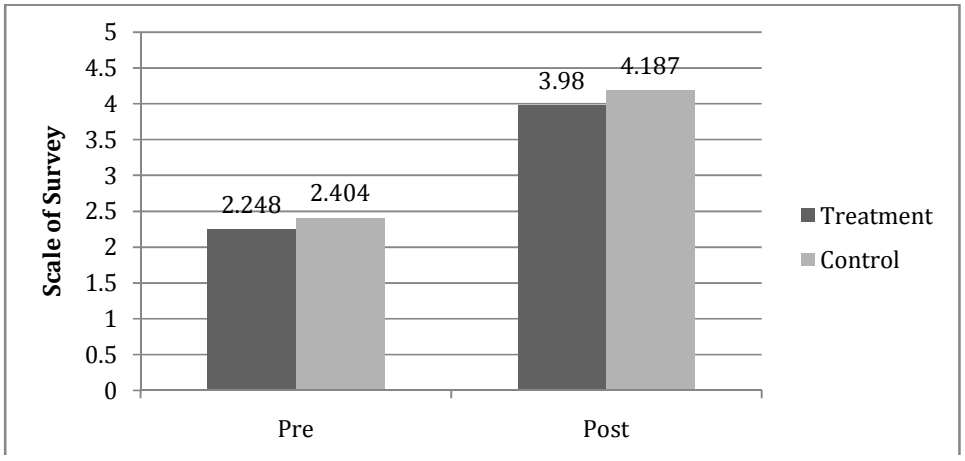

Figure 9: Fall 2009 Comparision of Attitudes: Average pre and post scores for control and treatment classes.

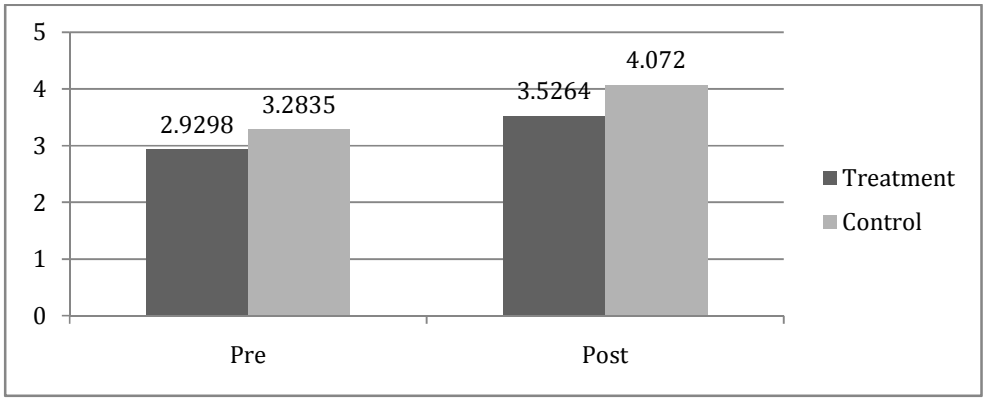

Figure 10: Fall 2009 Comparision of Skill: Average pre and post scores for control and treatment classes.

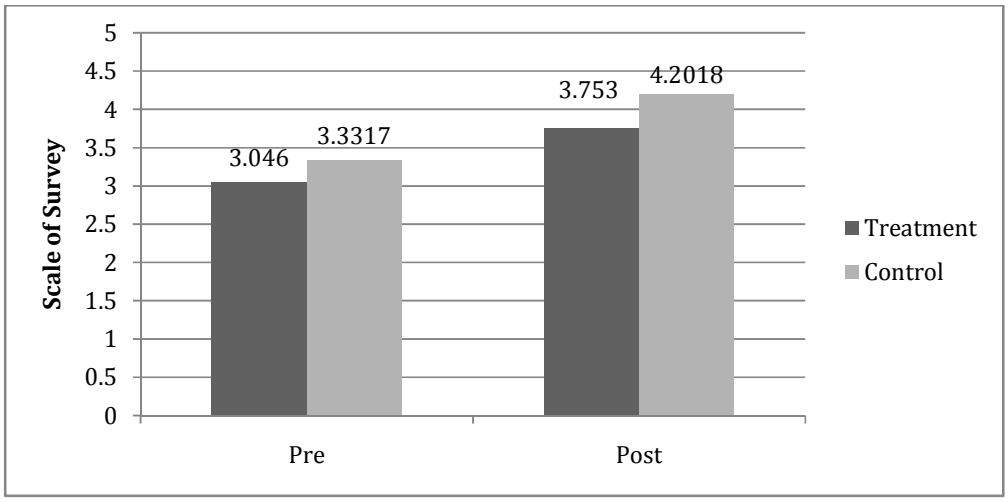

Figure 12: Fall 2009 Comparision of Integration of Learning: Average pre and post scores for control and treatment classes.