Effects of teaching strategies on student success, persistence, and perceptions of course evaluations

Marisela Rodriguez, Ed.D.
Laredo Community College

Marie-Anne Mundy, Ph.D.
Texas A & M - Kingsville

Lori Kupczynski, Ed.D.
University of St. Augustine for Health Sciences

Linda Challoo, Ed.D
Texas A & M - Kingsville

ABSTRACT

This study explored whether gender and active learning and student-centered pedagogies such as project-based and peer-led in introductory science "gatekeeper" major courses; BIOL 1306 and CHEM 1311 had an impact on student success rates, student perceptions, and student persistence in STEM fields at a community college in South Texas while controlling for the BIOL 1306 and CHEM 1311 pretest, respectively, was analyzed through the utilization of a 2-way ANCOVA. The effects of the three teaching strategies on student perceptions was measured by the student Course Evaluation instrument in BIOL 1306 and CHEM 1311 through a MANOVA statistical method. The relationship between the three teaching strategies and student persistence in pursuing a STEM major for BIOL 1306 and CHEM 1311 students was analyzed through a binary logistic regression method. Throughout the BIOL 1306 and CHEM 1311 sections, there were no significant (1) interaction between gender and teaching strategy, (2) differences among the three teaching strategies, and (3) difference between student genders on the variable of student success as measured by the BIOL 1306 and CHEM 1311 posttest while controlling for the BIOL 1306 and CHEM 1311 pretest, respectively. There were no significance differences seen among the three teaching strategies on student perceptions.

Keywords: teaching strategies, student persistence, STEM, student persistence

INTRODUCTION

Since the 21st century, major reports have identified the importance of STEM education and consequences the nation will face with STEM shortages. According to Hagedorn and Purnamasari (2012), there are numerous reports such as Before It's Too Late (National Commission on Mathematics and Science Teaching for the 21st Century, 2000) and Rising Above the Gathering Storm (Committee on Prospering in the Global Economy of the 21st Century, 2007) have warned the country that if a focus on improving STEM education is not made, the country will suffer dire consequences. Thus, the federal government has proclaimed the importance of increasing STEM education in the United States.

College student attrition regarding Science, Technology, Engineering, and Mathematics (STEM) majors typically occurs during the first or second year of a student's college experience (Seymour and Hewitt, 1997). A student's first year college courses play an influential role in the major students will decide to pursue. This study explored whether active learning and student-centered teaching strategies such as project-based and peer-led had an impact on student success rates, students' perceptions, and students' persistence in STEM fields at a community college in South Texas. Introductory science *gatekeeper* major courses evaluated were within the disciplines of general biology, BIOL 1306- Biology for Science Majors I, and chemistry, CHEM 1311- General Chemistry I. The three teaching strategies were lecture-based, project-based, and peer-led instruction.

RESEARCH QUESTIONS

The following questions provided the direction for this study:
RQ1: Does the type of teaching strategy; lecture-based, project-based, and peer-led instruction effect student success as measured by the posttests in BIOL 1306 and CHEM 1311 while controlling for the pretest in BIOL 1306 and CHEM 1311 respectively?
RQ2: Was there a significant difference between females and males on student success as measured by difference scores between pretest and posttest in BIOL 1306 and CHEM 1311?
RQ3: Was there a significant difference among the teaching strategy; lecture-based, project-based, and peer-led instruction on student perceptions of instructor's attitude toward student, instructor's delivery of course content, instructor's organization of the course, and instructor's evaluation of student performance as measured by the student Course Evaluation instrument in BIOL 1306 and CHEM 1311?
RQ4: Did the teaching strategies; lecture-based, project-based, and peer-led instruction predict student persistence in pursuing a STEM major?

REVIEW OF LITERATURE

According to the National Math and Science Initiative (2014), in 2008, 31 percent of U.S. bachelor's degrees were awarded in science and engineering fields. It was also noted that 38 percent of college freshmen who declared to be STEM majors did not graduate with a STEM degree. Hawley, Cardoso, and McMahon (2013) stated that an estimated 75% of high school graduates who have math and science aptitudes decided not to pursue a STEM major, and for those who did declare a STEM major in college, the attrition rate ranged between 40% and 60%.

The reason students switch majors is due to the design projects and discussion oriented learning that occurs in other non-STEM courses. These concerns and challenges have driven national efforts to address the absence of STEM graduates.

Gender Barriers in STEM

Another barrier that prevents students from completing STEM degrees was gender. Research indicated that female students were less likely to pursue STEM majors and STEM careers. Perrone, Sedlacek, and Alexander (2001) also indicated that females tend to steer away from STEM disciplines due to insufficient role models and limited confidence in entering STEM fields. Moakler and Kim (2014) conducted a study that determined a correlation between female students with low confidence in mathematics and lower probability of pursuing a STEM major choice. It was predicted that females might be more interested in STEM through development of their self-image, the promotion of STEM early throughout their childhood, interaction with female STEM mentors, and development of their mathematics skills. Weinburgh (1995) also found that there was a positive correlation between males positive attitude towards STEM and student achievement.

Minorities in STEM

There has also been an underrepresentation seen amongst minorities in STEM disciplines and majors. Hawley et al. (2013) indicated that race and ethnicity play an important role in student STEM retention. In addition, the National Academy of Sciences (2007) reported that even though African Americans and Latinas/os make up approximately 12% of the total U.S. population, they receive less than 5% of the STEM bachelor's degrees and doctorates awarded, respectively. The National Science Foundation (2009a) declared that minorities held just 10 percent of doctorates in STEM fields. Minorities make up ten to eleven percent of STEM majors which indicates there is under-representation seen amongst minorities in STEM fields (Griffith, 2010). Williams (2013) argues that the underrepresentation of minorities not entering STEM fields is due to factors that have negatively influenced minority students' success in STEM classes. These factors include: school district funding disparities, tracking into remedial courses, underrepresentation in Advanced Placement (AP) courses, unqualified teachers, low teacher expectations, stereotype threats, oppositional culture, and premature departure from high schools.

Skills Students Lack to Promote STEM Fields

Rice, Barth, Guadagno, Smith, and McCallum (2013) indicated that there are three factors hypothesized to affect students' willingness to pursue math and science coursework: student attitudes, self-perceived abilities, and social support in math and science. Studies indicated that students generally have more negative attitudes toward math and science compared to other academic areas. Studies indicated that student attitudes, interest, and efficacy towards math and science declines over the adolescent years, however a different pattern is seen between males and females. Eccles (1984) and Midgley (1989) have identified that attitudes toward math significantly decline for both boys and girls over the transition to junior high and during their junior high careers. It was also determined that boys had better math self-concepts than girls. In addition, Marsh and Yeung (1997) found that girls had better grades than boys yet showed poorer self-concepts, less confidence in their math ability, and less positive attitudes towards math and science. Rice et al. (2013) stated that generally, girls' self efficacy and attitudes decrease or stay stable in adolescence while boys have been shown to have decreasing (some research indicates it increases) attitudes and self-efficacy during adolescence.

Moakler and Kim (2014) utilized the *Social Cognitive Career Choice Model (SCCCM)* by Lent, Brown, and Hackett (1994) to examine the indicators that influence STEM major choices. The model evaluated factors such as personal experiences and background, learning experiences, self-efficacy, and outcome expectations. Self-efficacy and outcome expectations influence a student's academic interests, goal development, and career options. Moakler and Kim (2014) utilized the SCCCM as the conceptual framework and several positive indicators of STEM major choice were found. These indicators included: having parents with a STEM occupation, having higher SAT scores, having a higher high school GPA, having spent more hours studying or doing homework, being a minority (African American or Latina/o), having higher academic confidence, and having higher mathematics confidence (Moakler and Kim, 2014, p. 138). It was also found that being a female was shown as a negative predictor for STEM major choices.

Student Engagement and Active Learning Pedagogies in STEM Courses

One of the primary reasons students decided to switch majors is due to the lack of academic engagement in introductory STEM courses. Student engagement has been defined by scholars in multiple variations. However, Fredericks, Blumenfeld, and Paris (2004) defines engagement in three dimensions: behavioral, emotional, and cognitive. Behavioral engagement is defined by student involvement and participation throughout the course such as paying attention and asking questions (Birch and Ladd 1997). Emotional engagement refers to the students' feelings such as anxiety and excitement, and cognitive relates to the investment students make towards their learning and commitments (Connell and Wellborn 1991).

Introductory Courses' Instruction Affecting STEM Retention and Persistence

There has been a modern investment in STEM education that has focused on the introductory sequence science courses and finding ways to retain undergraduate majors. Beach, Henderson, and Finkelstein (2012) indicates that by shifting these courses from an instruction-or-teacher-centered to a learning-or student-centered paradigm, it can address high attrition rates, modeling best teaching practices (for all levels), and establishing educational practices that influence STEM disciplines.

Tseng (2013) conducted a study which focused on student attitudes towards science in order to understand student interest and self-concept in learning science. Tseng (2013) implied that teaching instruction is the major reason for negative attitudes and lack of interest in science curriculum due to the fact that science teachers focus mainly on theoretical understanding rather than practical work. Nolen (2003) emphasized that students find science curriculum to be boring due to the fact that instructors emphasize memorization in science learning.

Project-Based Instruction

Project-based learning allows students to work on complex problems and provides authentic experiences in order for students to find purposeful meaning to STEM concepts. Capraro (2013) defines project based learning as a teaching strategy that requires students to think critically and analytically, enhancing their higher-order thinking skills. Project-based learning involves students seeking a solution to complex problems situated within larger projects and justifying their results. Railsback (2002) also stated that project-based learning moves away from memorization and provides complex work that contains interdisciplinary disciplines and encourages cooperative learning. Project-based teaching strategies are a holistic method that is becoming more meaningful to students, especially those who have different learning styles, backgrounds, and abilities in which students are able to explore within the curriculum.

Peer-Led Instruction

Several findings indicated that a single introductory course can have an impact on student persistence by moving in the direction of changing pedagogy from lecture to Peer Instruction (PI). Peer Instruction (PI) is an interactive teaching tool that helps promotes student engagement. Peer-led instruction involves breaking large lectures into smaller workshop sections in which peer instructors facilitate cooperative group work, thus increasing student interaction. Research indicated that courses that incorporate activities that yield immediate feedback through discussion with peers and instructors result in better assessment scores and a better conceptual understanding than traditional courses.

Previous and current research shows that PI may be well suited to positively impact students both during the course and beyond the course. By integrating PI in the classroom, it addresses the many complaints that students have on STEM teaching in regards to poor quality. Watkins and Mazur (2013) stated that by incorporating and structuring peer discussions, students have more opportunities to get to share ideas and form a collaborative discussion within the introductory science classroom. During these discussions, the instructor is able to listen to the students and students are able to engage more in the lecture, which increase the faculty-student interaction. PI creates a more exciting classroom and a positive environment is seen between faculty member and students. These constant interactions and feedback, as seen in PI courses, allows an instructor to see the weaknesses of the students which will allow him or her to better tailor their instruction according to the students' needs. Lansiquot, Blake, Liou-Mark, and Dreyfuss (2011) also suggest that supportive learning environments are essential in helping undergraduates, particularly underrepresented minorities, in the fields of science and mathematic.

METHODOLOGY

This study examined whether active pedagogies throughout introductory *gatekeepe*r science courses, Biology for Science Majors I (BIOL 1306) and chemistry course, General Chemistry I- CHEM 1311, have an effect on student success, student perceptions, and students' persistence in pursuing a STEM major. The variables were measured and analyzed using the statistical methods of a 2-way ANCOVA, MANOVA, and binary logistic regression. This current study included three groups; lecture-based, project-based, and peer-led instruction classroom settings. There were two science courses examined, BIOL 1306 and CHEM 1311. Therefore, one class in BIOL 1306 and one class in CHEM 1311 was taught in a lecture-based instruction which was group one. Group two consisted of a class in BIOL 1306, and another class in CHEM 1311 that was taught in a project-based instruction. Group three consisted of a class in BIOL 1306 and another class in CHEM 1311 that was taught in peer-led instruction. The independent variables were the following types of teaching strategies; lecture-based, project-based, and peer-led instruction; and student gender; female and male. The dependent variables included student success, student perceptions of their course, and student persistence. The treatment groups included groups 2 and 3 from BIOL 1306 and CHEM 1311, which were classes taught in project-based and peer-led instruction, respectively. The control variable included the classes taught in lecture-based instruction in BIOL 1306 and CHEM 1311. The courses of BIOL 1306 and CHEM 1311 were analyzed separately. Student success were measured using difference scores between a pretest and posttest scores which assessed the student learning outcomes and core objectives of BIOL 1306 and CHEM 1311 as established by the Texas Higher Education Coordinating Board's *Academic Course Guide Manual.* The significant differences and interactions between females and males in each of the three groups (three different teaching strategies) on the variable of student success was measured by the BIOL 1306 and CHEM 1311 posttest while controlling for the pretest.

Besides student success, the other dependent variables included student perceptions of their course and student persistence. The student course perceptions included instructor's attitude toward student, instructor's delivery of course content, instructor's organization of course, and instructor's evaluation of student performance as measured by the student Course Evaluation instrument, and students persistence in pursuing a STEM major was measured by subsequent enrollment in science major courses.

Population and Sample

The sample included one college in southern Texas, particularly students enrolled in biology and chemistry introductory courses. The college was chosen as it was convenient and because there were teachers available who could teach using the different strategies. Sampling was purposive because the subjects were selected based on their enrollment in the introductory science courses of BIOL 1306 and CHEM 1311. These are the introductory *gatekeeper* courses that in theory dissuade a student from pursuing a STEM major. Studies indicated that students change majors due to poor teaching throughout the science courses and the lack of student engagement (Gasiewski et. al., 2012). Therefore, three sections of BIOL 1306; M01, M02, and M03 and three sections of CHEM 1311; M02, M03, and S01 were identified.

Instrumentation

Pre and Posttest

The pre and posttest was created by the science department faculty members at that same college where the study was conducted, and it was confirmed by the investigator. The pre and posttest included the assessment of student learning outcomes as established by the Texas Higher Education Coordinating Board within BIOL 1306 and CHEM 1311 courses. Throughout the courses of BIOL 1306 and CHEM 1311, the pre test was administered on the first day of class, and the posttest was administered on the last day of classes (one week before final exam). The differences between pretest and posttest scores were examined to measure the variable of student success. All records of each student were assigned the same de-identified number.

Student Course Evaluation

The student Course Evaluation was an instrument established by the same college where the study was conducted. The student Course Evaluation instrument contains a total of 25 questions. 2-3 weeks before the courses of BIOL 1306 and CHEM 1311 ended, student Course Evaluations were administered to the students enrolled in the classes. Their responses were collected as an aggregate percentage where student data was de-identified. All records of each student had the same de-identified number.

Banner System

The Banner software system generated a report which tracked if students enrolled in the subsequent science semester course. For example, students enrolled in BIOL 1306 and CHEM 1311 sections during the fall 2015 semester were examined and confirmed on their enrollment for science courses during the spring 2016 semester. The investigator received student records with de-identification numbers on an excel file. All records of each student had the same de-identified number.

Procedures

The following procedures took place:

1. Each course, BIOL 1306 and CHEM 1311, was taught by one professor who taught three separate sections utilizing a different teaching strategy in each of the three sections. There were three sections of BIOL 1306; M01, M02, and M03 and three sections of CHEM 1311; M02, M03, and S01 that were used for this study. Therefore, all sections of BIOL 1306 were taught by the same biology instructor and all sections of the CHEM 1311 were taught by the same chemistry instructor. The BIOL 1306 courses was capped at twenty-two students and taught by the same female instructor, and CHEM 1311 courses were capped at eighteen students and taught by the same male instructor. Students who enrolled in BIOL 1306 M01 and CHEM 1311 M02 during the fall 2015 semester were taught in lecture-based instruction. Students who enrolled in BIOL 1306 M02 and CHEM 1311 M03 during the fall 2015 semester were taught in project-based instruction. Students who enrolled in BIOL 1306 M03 and CHEM 1311 S01 were taught in peer-led instruction.
2. The course design for each of the sections: lecture-based, project-based, and peer-led instruction was created during four sessions between the biology instructor, chemistry instructor, and investigator. The first session included the investigator conducting a workshop where the BIOL 1306 and CHEM 1311 instructor were introduced to each of the teaching methods; lecture-based, project-based, and peer-led instruction. In this session, the instructors received a formal understanding of the three teaching strategies. On the second session, discussions of the understanding of each of the teaching strategies took place and a checklist was created (by the biology instructor, chemistry instructor, and investigator) which identified the characteristics of each of the teaching strategies. This checklist helped guide the design and activities of each of the

sections that the instructors were expected to teach. On the third session, the checklist that was created from the second session was used to drive the design of the activities and assessments for each of the teaching strategies. In this session, the instructors applied the checklist to the activities that they intended to implement throughout the three teaching strategies. During the fourth session, the activities that were discussed throughout the third session were applied to the syllabus of the instructors' course. Each instructor was expected to submit three different syllabi that complemented the three teaching strategies. A final draft of the syllabus needed to be discussed and approved by the biology instructor, chemistry instructor, and investigator one week before classes resumed. In this way, before the fall 2015 semester began, the instructors for BIOL 1306 and CHEM 1311 understood the concepts of the three teachings strategies and also understood to only implement the teaching strategy that was assigned for the class.

3. During the first week of classes (on the first day), a pretest in BIOL 1306 and CHEM 1311 was distributed to students depending on the respective class that they were enrolled. A BIOL 1306 pretest was administered to students enrolled in BIOL 1306 courses, and a CHEM 1311 pretest was administered to students enrolled in CHEM 1311 courses. The responses were collected by the instructor, deidentified, and delivered to the investigator. An analysis was conducted at the end of the semester.
4. Two to three weeks before the semester ended, students went to a computer lab and completed their student Course Evaluation instruments. Lab coordinators for the department conducted the administration of the evaluations. Students completed their evaluations via PasPort system. The students had two options to access the student Course Evaluation instrument. Option one included the student logging into PasPort, selecting the "Student Tab", finding "Student Quick Links", and clicking on "Student Evaluations". The student ID included their student identification number (PID number) and the password was their date of birth. In option two the students accessed an url which was accessed via smartphone with internet access, and logging in using their PasPort username and PasPort password. The results were collected by the Information Technology staff members and were sent to the investigator using students' de-identified numbers.
5. A week before final exams, a posttest in BIOL 1306 and CHEM 1311 was distributed to students depending on the respective class in which they were enrolled. A BIOL 1306 posttest was administered to students enrolled in BIOL 1306 courses, and a CHEM 1311 posttest was administered to students enrolled in CHEM 1311 courses. The responses were collected by the instructor and delivered to investigator using the same de-identifiable number as the pre-test. An analysis was conducted, and the difference scores between pretest and posttest scores was evaluated for each of the three groups. Scores were compared between all groups, and separately for the two courses.
6. During the spring 2016 semester, students were tracked utilizing the banner system. Students' subsequent enrollment in the science courses was examined. The investigator collected subsequent enrollments by the science faculty through de-identified numbers using an excel file.
7.

RESULTS

The student sample was certified after the twelfth class day during the fall 2015 semester. For the lecture-based courses, twenty-three students enrolled in BIOL 1306 M01 and twenty-one students enrolled in CHEM 1311 M02. Within the project-based courses, twenty-one students enrolled in BIOL 1306 M02 and twenty-two students enrolled in CHEM 1311 M03. In the peer-led instruction courses, twenty-three students enrolled in BIOL 1306 M03 and eighteen students enrolled in CHEM 1311 S01.

Females performed lower than males within all teaching strategies; lecture based (M= 49.40, SD= 10.02, N=10 compared to M=60.50, SD= 13.27, N=10); project based (M=53.07, SD= 15.90, N=14 compared to M=61.40, SD= 4.77, N=5); and in the peer led instruction, (M=57.00, SD= 13.87, N=16 compared to M=57.60, SD= 14.54, N= 5) (Table 1).

The students' gender was analyzed separately. Females performed better in the peer led instruction (M=57.00, SD= 13.87, N=16) compared to project based instruction (M=53.07, SD= 15.90, N=14) and lecture based (M=49.40, SD= 10.02, N=10). Whereas, the males performed better in project based instruction (M=61.40, SD=4.77, N=5) compared to lecture based (M=60.50, SD=13.27, N=10) and peer led instruction (M=57.60, SD= 14.54, N=5). "as indicated in Table 1 (Appendix)".

A two-way ANCOVA was conducted for the three BIOL 1306 sections. A preliminary analysis was conducted to evaluate the homogeneity of slopes between the covariate (pretest) and the dependent variable across the three groups and was met. The partial η^2 for the interaction was .007, indicating that the effect size was small and the three teaching strategies accounted for less than 1% of the variance of dependent variable, pottests.

The interaction between gender and teaching strategies of posttest scores was evaluated. The regression line was highest for males in the peer-led instruction (Mean= 57.936) group, whereas the lecture-based (Mean= 57.157) and project-based (Mean = 51.051) groups were lower and lowest, respectively. The regression line was highest for females in the lecture-based (Mean= 57.442) group, whereas the peer-led (Mean= 56.493) and project-based (Mean= 53.870) groups were lower and lowest, respectively. However, the interaction effect was nonsignificant, $F(2,53) = .18$, $p= .836$, partial $\eta^2= .007$, possibly due to the lack of power observed which was .076. The effect size was small and accounted for less than 1% of the variance for the dependent variable.

Simple main effects tests were conducted to assess differences among teaching strategy groups; lecture-based (Mean= 57.300), project-based (Mean= 52.461), and peer-led (Mean= 57.214) values on the covariate. The independent pairwise comparisons among the estimated marginal means were nonsignificant, $F (2,53)= 1.212$, $p=.306$, $\eta^2= .044$. The effect size was small and accounting for 4% of the variance for the dependent variable.

In addition, simple main effects tests were conducted to assess differences between females (Mean= 55.935) and males (Mean=55.381) on the covariate which was the pre-test. The independent pairwise comparisons among the estimated marginal means was nonsignificant, $F(1,53)= .036$, $p=.850$, $\eta^2= .001$. The effect size was neglible and accounted for less than .1% of the dependent variable.

An additional two-way ANCOVA was conducted for the three CHEM 1311 sections. In the lecture based instruction the females performed higher in posttest scores (M= 70.00, SD=15.32, N=14) than males (M=56.75, SD= 21.56, N=4). During the project-based instruction, the females performed lower in posttest scores (M=70.89, SD=16.87, N=9) compared to males (M=73.36, SD= 13.22, N= 11). In addition, in the peer led instruction, the females performed lower in posttest scores (M=63.13, SD= 12.98, N=8) compared to males (M=67.80, SD= 8.76, N= 5). Females had higher posttest scores in a project based course design (M=70.89, SD= 16.87, N=9) compared to lecture based instruction (M=70.00, SD= 15.32, N=14) and peer led instruction (M=63.13, SD= 12.98, N=8). Whereas the males showed higher posttest scores in project based

instruction (M=73.36, SD=13.22, N=11) compared to peer led instruction (M=67.80, SD=8.76, N=5) and lecture based instruction (M=56.75, SD= 21.56, N=4). (Table 2)
"as indicated in Table 2 (Appendix)".

A preliminary analysis was conducted to evaluate the homogeneity of slopes between the covariate (pretest) and the dependent variable across the three groups and was met. The partial η^2 for the interaction was .046 indicating that the effect size was small and accounted for less than 5% of the variance of dependent variable.

The interaction between gender and teaching strategies of posttest scores throughout chemistry courses was evaluated. The regression line was highest for males in the project-based (Mean= 74.041) group, whereas the peer-led (Mean = 64.630) and lecture-based (Mean= 56.790) groups were lower and lowest, respectively. The regression line was highest for females in the project-based (Mean= 72.574) group, whereas the lecture-based (Mean= 69.594) and peer-led (Mean= 62.970) groups were lower and lowest, respectively. However, the interaction effect was nonsignificant, $F(2,44) = 1.053$, $p= .358$, partial $\eta^2= .046$, possibly due to the lack of power observed which was .222. The effect size was small for it accounted for less than 5% of the variance for the dependent variable.

Similar to previous results from BIOL 1306 courses, simple main effects tests were conducted for the CHEM 1311 courses to assess differences among teaching strategy groups; lecture-based (Mean= 63.192), project-based (Mean= 73.307), and peer-led (Mean= 63.800) values on the covariate. The independent pairwise comparisons among the estimated marginal means was nonsignificant, $F(2,44)= 2.277$, $p=.115$, $\eta^2= .094$. The effect size was small and accounted for 9% of the variance for the dependent variable.

In addition, simple main effects tests were conducted to assess differences between females (Mean= 68.379) and males (Mean=65.153) on the covariate which was the pretest. The independent pairwise comparisons among the estimated marginal means was nonsignificant, $F(1,44)= .500$, $p=.483$,
$\eta^2= .011$. The effect size was negligent for it only accounted for about 1% of the variance for the dependent variable.

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the three teaching strategies; lecture-based, project-based, and peer-led instruction on the four dependent variables; student perceptions of instructor's attitude toward student, instructor's delivery of course content, instructor's organization of course, and instructor's evaluation of student performance as measured by the student Course Evaluation instrument in BIOL 1306 courses. As illustrated in Table 3, for the domain or instructor's attitude toward student, the project based course had higher ratings on the course evaluation (M=4.94, SD= .18, N= 18) compared to lecture based (M=4.90, SD= .28, N=19) and peer led instruction (M=4.86, SD= .39, N=21). For the domain pertaining to instructor's delivery of course content, project based (M=4.93, SD= .19, N= 18) and peer led instruction (M= 4.93, SD= .28, N= 21) demonstrated higher ratings compared to lecture based instruction (M=4.89, SD=.28, N=19). For the domain, instructor's organization of the course, project based showed higher ratings (M= 4.94, SD= .16, N= 18) compared to lecture based (M=4.90, SD=.25, N=19) and peer led instruction (M=4.88, SD= .37, N= 21). For the domain of instructors evaluation of student performance, lecture based showed the higher ratings (M=4.91, SD= .28, N=19) compared to project based (M=4.90, SD= .26, N=18) and peer led instruction (M=4.87, SD= .34, N= 21).
"as indicated in Table 3 (Appendix)".

Significant differences were not found among the three teaching strategies on student perceptions based on the Course Evaluation instrument, Wilk's Λ=.87, F(8, 104)=.935, *p*= .491. The multivariate η^2 based on Wilk's Λ was small, .067.

A second one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the three teaching strategies; lecture-based, project-based, and peer-led instruction on the four dependent variables; student perceptions of instructor's attitude toward student, instructor's delivery of course content, instructor's organization of course, and instructor's evaluation of student performance as measured by the student Course Evaluation instrument in CHEM 1311 courses. As illustrated in Table 4, for the domain for instructor's attitude toward student, the peer led instruction showed higher ratings on the course evaluation (M=4.97, SD= .11, N= 17) compared to project based (M=4.96, SD= .18, N=18) and lecture based instruction (M=4.84, SD= .36, N=21). For the instructor's delivery of course content, peer led instruction showed higher ratings (M=4.96, SD= .13, N= 17) compared to project based (M= 4.92, SD= .26, N= 18) and lecture based instruction (M=4.86, SD=.33, N=21). For the domain, instructor's organization of the course, project based showed higher ratings (M= 4.93, SD= .24, N= 18) compared to peer led instruction (M=4.91, SD=.19, N=17) and lecture based instruction (M=4.81, SD= .35, N= 21). For the domain of instructors evaluation of student performance, peer led instruction showed the higher ratings (M=4.90, SD= .23, N=17) compared to lecture based (M=4.83, SD= .36, N=21) and project based instruction (M=4.81, SD= .32, N= 18).
"as indicated in Table 4 (Appendix)".

No significant differences were found among the three teaching strategies on the dependent measures, student perceptions based on the Course Evaluation instrument, Wilk's Λ =.802, F(8, 100)=1.462, *p*= .181.

A binary logistic regression was performed to ascertain the effects of the three teaching strategies; lecture-based, project-based, and peer-led instruction on student persistence in pursuing a STEM major throughout the biology sections. Lecture based instruction showed that nineteen students did pursue a STEM course(s) while four students did not pursue STEM. Meanwhile, peer led instruction demonstrated that sixteen students did pursue STEM compared to seven who did not. Project based instruction only had five students pursuing STEM compared to sixteen who did not want to pursue STEM (Table 5).
"as indicated in Table 5 (Appendix)".

The Cox and Snell R Square values were evaluated to explain the variations between the dependent variable. Therefore, in BIOL 1306 courses, the explained variation in the dependent variable based on the model summary was .23. The effect size was low which indicated 23% of the variance of the dependent variable was accounted for by the teaching strategies. The binomial logistic regression estimated the probability of student pursuing a STEM major is greater than .500, the percentage of students pursuing a STEM major was 87.5%. The Wald test was used to determine statistical significances for each of the teaching strategies (independent variables). The statistical significance of the test was found in lecture-based (Wald test= 14.63, *p*= .001) and peer-led instruction (Wald test= 8.46, *p*= .004), whereas project-based instruction was nonsignificant (Wald test= 1.05, *p*=.305).

Another binary logistic regression was performed to ascertain the effects of the three teaching strategies; lecture-based, project-based, and peer-led instruction on student persistence in pursuing a STEM major throughout the chemistry sections. Lecture based instruction showed that thirteen students did pursue a STEM course(s) while eight students did not pursue STEM.

Project based instruction demonstrated that twelve students did pursue STEM compared to ten who did not. Peer led instruction only had eight students pursuing STEM compared to ten who did not want to pursue STEM (Table 6).
"as indicated in Table 6 (Appendix)".

The Cox and Snell R Square values were evaluated to explain the variations between the dependent variable. Therefore, in CHEM 1311 courses, the explained variation in the dependent variable based on the model range is .019. This indicates that effect size is weak which accounts for less than 2% of variance for dependent variable. The binomial logistic regression estimated the probability of student pursuing a STEM major is greater than .500, the percentage of students pursuing a STEM major was 75.8%. The Wald test was used to determine statistical significances for each of the teaching strategies (independent variables). No statistical significance of the tests were found in lecture-based (Wald test= 1.180, p=.554), project-based (Wald test= 1.176, p= .278), and peer-led instruction (Wald test= .403, p= .526).

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

This current study analyzed the skills, particularly student learning outcomes, that students gained by enrolling into BIOL 1306 and CHEM 1311 courses. This study focused on BIOL 1306 and CHEM 1311 courses due to the fact that Seymour and Hewitt (1997) indicated that student performances throughout science introductory courses are the key indicators as to whether a student will switch out of their intended STEM majors. It is essential for educators to understand the skills and knowledge students gain during these introductory courses as well as whether these courses encourage or discourage a student from pursuing a STEM major. Throughout this current study, student success was investigated to further understand STEM education. Student success was measured using posttest scores while controlling for pretest scores, which assessed the student learning outcomes of BIOL 1306 and CHEM 1311 as established by the Texas Higher Education Coordinating Board*'s Academic Course Guide Manual*.

Besides focusing on student success by measuring student learning outcomes per posttest, this current study evaluated three different teaching strategies. Gasiewski, Eagan, Garcia, Hurtado, and Chang (2012) indicated that high attrition rates are related to several factors including reliance on large lecture based courses and the lack of engaging pedagogy. Therefore, three teaching strategies were evaluated within three different sections (within BIOL 1306 and CHEM 1311 courses) which included lecture based, project based, and peer led instruction. The three teaching strategies were investigated to detect whether there was an effect on student success. In this way, the teaching strategy utilized could better detect whether it was motivating and engaging students or serving as a *gatekeeper* course. Project based and peer led are two engaging teaching methods that have been shown improve student learning. In fact, the Buck Institute for Education (BIE) has determined that project based learning contains significant content in which student projects focus on students' knowledge and skills that also help build 21st century competencies such as problems solving and critical thinking. On the same note, Gosser (2015) has identified peer led instruction as a teaching strategy that improves student learning due to small peer groups engaging in course material and problem solving.

Despite poor teaching quality in science introductory courses and the lack of engaging teaching strategies, other barriers such as gender have contributed to the success of students pursuing STEM majors and careers. Moakler and Kim (2014) determined a correlation between females with low confidence in mathematics and lower probability of pursuing a STEM major course. The study also predicted that females were more interested in STEM through development of self-image. Therefore, in this current study gender was an important independent variable to evaluate student success as well as the effects of the teaching strategies. This current study indicated that females scored higher on their posttest through the implementation of peer led instruction. If females show low confidence and struggle with self-image, then peer led instruction gives these students an opportunity to address questions and challenge concepts, integrate problem solving strategies, and collaborate on modules that are conducive to meaningful group discussions. Lansiquot et al. (2011) indicated that these opportunities allow students to discuss their understanding of their science concepts in a “nonthreatening environment.”

Hewitt (1997) indicated that the main reasons why students lost interest in science were due to poor teaching. Students defined poor quality of teaching due to the experiences they encountered in the class such as faculty members lacking faculty-student interaction, preparation and organization, and enthusiasm. Tinto (1993, 2000) has indicated that a strong association between faculty and students increases student learning and engagement because faculty members shape the climate and culture of the classroom setting. If students feel comfortable with their instructors, then they will contribute to classroom discussions and more engagement will be seen. According to Gasiewski (2012), academic engagement is dependent on the classroom context, particularly with the interchange between the instructor and the students. This led this current study to further evaluate the effects of three teaching strategies on student perceptions. Student perceptions concerning instructor’s attitude toward student, instructor’s delivery of course content, instructor’s organization of course, and instructor’s evaluation of student performance as measured by the student Course Evaluation instrument were examined. The findings of this study indicated that throughout the courses of BIOL 1306, project based instruction showed higher means of course evaluation ratings for three domains: instructor’s attitude toward the student, instructor’s delivery of course content, and instructor’s organization of course. Throughout the courses for CHEM 1311, peer led instruction showed higher means of course evaluations for three domains: instructor’s attitude toward the student, instructor’s delivery of course content, and instructor’s evaluation of student performance. This current study indicated that both the project based (in BIOL 1306) and peer led (CHEM 1311) showed positive relationships between teaching strategies and students’ perceptions. This complements Tseng’s (2013) study that engaging student learning environments created positive student perceptions. Overall, the current study’s findings also indicated that all three teaching strategies showed high ratings on the student course evaluations. Both instructors’ evaluations amongst the three sections showed similar ratings amongst the four domains that focused on the instructors’ organization of the course, attitude towards student, instructor’s delivery of course content, and evaluation of student performance. Therefore, it can be assumed that the teaching strategy itself may not influence student perceptions, yet the faculty-student relationship may play a bigger effect on student perceptions. These results may have enhanced a positive learning environment where students felt comfortable to ask questions and be engaged towards their learning. It may be assumed that the engagement of student learning is contributed mainly towards the classroom climate and faculty-student relationship rather than a type of teaching strategy.

Student persistence is important to evaluate due to the fact that Hawley et al. (2013) stated that undergraduate students have a tendency of switching majors. There is an estimated 75% of high school graduates who have math and science aptitudes and then decided not to pursue

STEM, and for those who did declare a STEM major in college, the attrition rate ranged between 40% and 60%. Hawley et al. (2013) also concluded that the reason students switch majors is due to the design projects and discussion oriented learning that occurs in other non-STEM courses. Therefore, this current study evaluated the three teaching strategies; lecture based, project based, and peer led on student persistence. The evaluation of three teaching strategies was important due to the fact that Hawley et al. (2013) indicated that course design effects student persistence. In this study, a statistical significance was found in lecture-based and peer-led instruction within BIOL 1306, whereas project-based instruction showed not to be a significant prediction to student persistence in pursuing a STEM major. Throughout CHEM 1311 courses, no statistical significances were found in lecture-based, project-based, and peer-led instruction. In this study, none of the teaching strategies showed a significant prediction on student persistence in pursuing a STEM major within CHEM 1311 students.

Besides course design, literature also indicates other barriers and educational gaps that prevent a student from pursuing STEM. Gayles and Ampaw (2011) have also indicated that there has been a lot of national attention on the loss of women pursuing STEM fields. Perrone et al. (2001) indicated that females tend to steer away from STEM disciplines due to insufficient role models and limited confidence in entering STEM fields. Griffith (2010) also indicated that minorities make up ten to eleven percent of STEM majors which indicates there is under-representation seen amongst minorities in STEM fields.

One way that STEM education can be improved is by transforming or reforming science introductory courses. In order to transform classrooms, STEM educators should focus on student centered and active engaging teaching strategies. The discipline-based education research (DBER) has declared “student centered” instructional approaches have served as one form of evidence that highlights the positive effects of promoting and retaining STEM majors. Hawley et al. (2013) indicated that students switch majors due to design projects and discussion orientation learning that occurs in non-STEM courses. Conducting active student engagement involves the transformation of traditional learning designs and teaching strategies. There is insufficient literature to ensure that active learning designs and teaching strategies will improve STEM understanding, retention, interest, and student success rates. Therefore, this current study explored whether active learning and student centered teaching strategies such as project based and peer led had an impact on student success rates, students’ perceptions and students’ persistence in STEM fields within science introductory courses. Within this current study, it was found that peer led and lecture based instruction did significantly predict the criterion variable, student persistence in pursuing a STEM major within BIOL 1306. In this case, it was found that an engaging teaching strategy, such as peer led, and a non-engaging teaching strategy, such as lecture based, had an effect on student persistence. This contradicts the literature that indicates that active learning environments have a positive effect on student retention due to the fact project based was not significant and lecture based instruction was significantly effective. Therefore, a focus centered on active learning designs and teaching strategies is needed to fully understand whether lecture based courses do need to be transformed into active student-centered environments. A focus on improving STEM education is essential to make better conclusions about the student learning, attitudes, and retention. Improving STEM education and student persistence requires a close collaboration between STEM teachers, students, and administrators. This concern and challenge have driven national efforts to address the absence of STEM graduates. By increasing STEM graduates, more efforts need to focus on funding, developing new curriculum, effective science teacher training, and increasing the participation of minorities and women.

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APPENDIX

Table 1
Mean and Standard Deviations on Posttest Scores for Gender and Teaching Strategies in BIOL1306

Gender	Teaching Strategy	Mean	Standard Deviation	N
Female	Lecture-Based	49.40	10.02	10
	Project-Based	53.07	15.90	14
	Peer-Led	57.00	13.87	16
	Total	53.73	13.81	40
Male	Lecture-Based	60.50	13.27	10
	Project-Based	61.40	4.77	5
	Peer-Led	57.60	14.54	5
	Total	60.00	11.61	20
Total	Lecture-Based	54.95	12.78	20
	Project-Based	55.26	14.20	19
	Peer-Led	57.14	13.66	21
	Total	55.82	13.36	60

Table 2
Mean and Standard Deviations on Posttest Scores for Gender and Teaching Strategies in CHEM 1311

Gender	Teaching Strategy	Mean	Standard Deviation	N
Female	Lecture-Based	70.00	15.32	14
	Project-Based	70.89	16.87	9
	Peer-Led	63.13	12.98	8
	Total	68.48	15.08	31
Male	Lecture-Based	56.75	21.56	4
	Project-Based	73.36	13.22	11
	Peer-Led	67.80	8.76	5
	Total	68.65	14.98	20
Total	Lecture-Based	67.06	17.13	18
	Project-Based	72.25	14.61	20
	Peer-Led	64.92	11.38	13
	Total	68.55	14.89	51

Table 3
Means and Standard Deviations on Student Perceptions for the Three Teaching Strategies in BIOL 1306

Student Perceptions	Teaching Strategy	Mean	Standard Deviation	N
Instructor’s Attitude	Lecture-Based	4.90	.28	19
Toward Student	Project-Based	4.94	.18	18
	Peer-Led	4.86	.39	21

	Total	4.90	.30	58
Instructor's Delivery of Course Content	Lecture-Based	4.89	.28	19
	Project-Based	4.93	.19	18
	Peer-Led	4.93	.28	21
	Total	4.91	.25	58
Instructor's Organization of Course	Lecture-Based	4.90	.25	19
	Project-Based	4.94	.16	18
	Peer-Led	4.88	.37	21
	Total	4.91	.28	58
Instructor's Evaluation of Student Performance	Lecture-Based	4.91	.28	19
	Project-Based	4.90	.26	18
	Peer-Led	4.87	.34	21
	Total	4.89	.29	58

Table 4

Means and Standard Deviations on Student Perceptions for the Three Teaching Strategies in CHEM 1311

Student Perceptions	Teaching Strategy	Mean	Standard Deviation	N
Instructor's Attitude Toward Student	Lecture-Based	4.83	.36	21
	Project-Based	4.96	.18	18
	Peer-Led	4.97	.11	17
	Total	4.91	.25	56
Instructor's Delivery of Course Content	Lecture-Based	4.86	.33	21
	Project-Based	4.92	.26	18
	Peer-Led	4.96	.13	17
	Total	4.91	.26	56
Instructor's Organization of Course	Lecture-Based	4.81	.35	21
	Project-Based	4.93	.24	18
	Peer-Led	4.91	.19	17
	Total	4.88	.28	56
Instructor's Evaluation of Student Performance	Lecture-Based	4.83	.36	21
	Project-Based	4.81	.32	18
	Peer-Led	4.90	.23	17
	Total	4.84	.31	56

Table 5

Frequencies of Students Pursuing STEM Major for Teaching Strategies in BIOL 1306

Teaching Strategy	N students pursuing STEM	N Students not pursuing STEM	Total
Lecture-Based	19	4	23
Project-Based	5	16	21
Peer-Led	16	7	23

Table 6

Frequencies of Students Pursuing STEM Major for Teaching Strategies in CHEM 1311

Teaching Strategy	N students pursuing STEM	N Students not pursuing STEM	Total
Lecture-Based	13	8	21
Project-Based	12	10	22
Peer-Led	8	10	18