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The effects of the peer instruction technique Think-Pair-Share on students' performance in chemistry

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THE EFFECTS OF THE PEER INSTRUCTION TECHNIQUE THINK-PAIR-SHARE ON STUDENTS' PERFORMANCE IN CHEMISTRY

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Abstract

Think-Pair-Share is an active learning strategy which involves pairs of students discussing answers to questions or problems. The purpose of this study was to determine if the peer instruction technique Think-Pair-Share improved students' performance in high-school chemistry. The teacher used one class of students as a control group. This group did not use Think-Pair-Share for the chapter investigated, "Chemical Reactions". The teacher used two other classes of students, who did use Think-Pair-Share for this chapter, as the experimental group. There was no difference in the learning gains between the control and experimental groups. Think-Pair-Share and normal classroom instruction methods were equally effective. Factors such as small class size, absenteeism, quality of pre- and post-test questions, and the reluctance of the control group to stop using Think-Pair-Share may have contributed to these results. These issues are addressed, and a new, improved study design is suggested.

Introduction

Education in Louisiana is changing. The state is adopting more rigorous academic standards and assessments, and teachers are being held accountable for getting their students to perform at these levels. Educators need to adopt new teaching methods to prepare their students to meet these new challenges. One of these methods, peer instruction, actively engages students in the learning process and has been shown to improve student performance (Crouch et al. 2007).

Academic standards in Louisiana changed in 2010. This was when the Department of Education adopted the Common Core State Standards in English and math. These standards were developed by a national group of educators and have been adopted in forty-five states. Common Core standards, applied across all grade levels, were designed to make sure students were prepared for either college or a career after high school. To meet that objective, the standards were more rigorous than previous standards, requiring students to master complex material (http://www.louisianabelieves.com/academics/common-core-state-standards).

New assessments are being developed to go along with the Common Core State Standards. Starting in 2014, Louisiana will begin using assessments developed by the Partnership for Assessment of Readiness for College and Careers (PARCC). PARCC exams will take the place of current standardized tests, including LEAP and end-of course exams. Questions on the PARCC exams will be open-ended and require students to provide a written response. For example, students will be required to provide a written explanation of how they solved a math or science problem (http://www.louisianabelieves.com/docs/assessment-transition/transition-to-parcc-memo.pdf?sfvrsn=6).

To enable their students to master the new, rigorous standards and assessments, educators need to use a variety of teaching methods. Peer instruction, a type of active learning or collaborative learning, can help teachers meet the new challenges they face. Peer instruction is "an instructional strategy for engaging students during class through a structured questioning process that involves every student" (Crouch et al. 2007). The main focus of this strategy is to actively engage students in the learning process. It was used by Eric Mazur in his college-level physics courses to increase students' participation and determine students' misconceptions (Mazur 1997). Studies done in college classes show that peer instruction is an effective teaching strategy.

College-level physics students have benefited from peer instruction. Physics instructors from eleven different colleges and universities pre-tested their students using the Force Concept Inventory (FCI). They then taught their physics course. Thirty of these instructors' courses were taught using some type of peer instruction. At the end of the course, the FCI was given again as a post-test. The classes that were taught using peer instruction had an average learning gain from pre-test to post-test of 39%. The gains for courses that did not use a peer instruction technique were not discussed in the paper. The authors of this study did not determine if these results were statistically significant (Fagen et al. 2002).

Peer instruction has been shown to improve students' ability to solve problems and correct errors they made when solving a problem. Giuliodori, Lujan, and DiCarlo (2006) studied whether peer instruction helped veterinary students in a physiology class solve problems. In this experiment, students received instruction on a specific topic. They were then presented a problem based on the topic and asked to solve it. Students were given a minute to solve the problem and write down their answer. The students then discussed their answer with a group of

their peers. If a student decided to change an answer after the discussion, the student was instructed to write down the new answer along with an explanation of why the answer was changed. This was done four to six times during a 90 minute class. The answers the students gave when they worked the problem individually were compared to the answers they gave after they consulted with their peers. Individually, students got problems correct 53% of the time. After they discussed the answer with a partner, correct responses occurred 80% of the time ($p < 0.05$). This experiment also showed that 57% of the students who initially had the answer to a problem wrong changed their answer to the correct one after peer instruction took place (Giuliodori et al. 2006).

Many different methods of peer instruction exist. These methods can be used to enhance the teaching of many different subjects by actively involving students in class (Barkley et al. 2005). Some of these methods, such as Jigsaw, involve students working in groups. Others, such as Think-Aloud Pair Problem Solving and Think-Pair-Share, involve students working in pairs. These methods can be used by college and high school classes and are suitable for large and small groups.

Jigsaw is a strategy that involves students working in groups to become experts on a specific topic. A class using Jigsaw is divided into several groups on specific topics. Students are assigned to the topic groups, and with their peers in those groups, learn the material and become experts on that topic. Then one student from each topic group is assigned to a new group. Each student expert then teaches the members of the new group about the specific topic (Barkley et al. 2005).

The effectiveness of the jigsaw strategy was studied in college-level general chemistry classes (Doymus 2007). Two classes of students were used as the subjects of this study. Fifty two students were in an experimental group that used Jigsaw, and 56 were in a control group that did not use Jigsaw. The specific topics being investigated were phases of matter and phase diagrams. Students in both groups were pre- and post-tested using a chemistry concept test, were taught the same curriculum, and received the same amount of instructional time. In the class that used Jigsaw, students became experts in information dealing with either solids, liquids, or gases. Then those student formed new groups. Each new group had a member from the solid, liquid, and gas groups. Each student expert then taught their new group what they learned in their topic group. Students who used Jigsaw scored higher on the post-test, with a mean score of 21.50 out of 30, than students who did not use Jigsaw, whose mean score was 18.80 ($p < 0.05$). The author concluded that Jigsaw helped students learn how to use phase diagrams (Doymus 2007).

Think-Aloud Pair Problem Solving (TAPPS) is a peer instruction technique that involves students working in pairs to solve problems. One student in the pair is assigned the role of problem-solver, and the other student is assigned the role of listener. The problem-solver works a given problem, describing out loud how he is solving the problem. His partner listens to this explanation and gives feedback on the problem-solving technique used. Students in each pair will switch roles either during the same class or for the next class session. This strategy helps students learn and refine problem-solving techniques (Barkley et al. 2005).

A study by Noh et al. (2005) examined the effect that TAPPS can have on students' problem-solving ability. Eighty-five students from a boys' high school in South Korea were divided into three different groups. One group, the control group, only used examples in the textbook to help them solve problems. Two other groups were taught a problem-solving strategy

that involved students identifying givens and unknowns, planning how to solve the problem, solving the problem, and reviewing their work. One of these groups used the problem-solving strategy on their own, and the other group used the problem-solving strategy and TAPPS. All three groups were taught lessons on gas laws and solutions during the first part of class, then assigned problems to work. Students worked the problems using the method of the group they were assigned to. After the teacher had covered the course material, students were given a problem-based test. Students in the TAPPS group scored higher on this test, with an average score of 11.44 questions correct out of 15, than the other two groups. The control group only scored an average of 6.21 points ($p = 0.002$). The authors concluded that TAPPS may help students perform better on tests that involve problem-solving (Noh et al. 2005).

Think-Pair-Share involves students discussing answers to questions with each other. The teacher asks the class a question and gives students a set amount time to answer the question individually. Then the teacher tells the students to turn to someone sitting next to them and discuss their answer. Students are given time to discuss their answers with their partner. If the answers differ, one partner tries to convince the other that his answer is the correct one (Barkley et al. 2005). Using Think-Pair-Share helps a student get the correct answer even if neither student nor his partner knew the correct answer to start with.

A study conducted by Smith et al. (2009) attempted to determine if students were really learning information from Think-Pair-Share or if they were just picking the most popular answer to a question. This study involved 350 students in an introductory genetics class. Students were presented with a question during the course of a lecture and were instructed to respond to it by using a clicker. Students were then asked turn to a student next to them and discuss their answer to the question. Students were then given the option to change the answer to the question but

were not given the correct answer. Later in the lecture the students were given a similar question and again asked to answer it by using a clicker. Students were then given the correct answer to both of the questions. The results showed that students benefited from discussing the answer to the first question with a partner. Fifty-two percent of the students got the answer correct before the discussion. After discussing the question, 68% correctly answered the question. In addition, 73% of students were then able to answer a similar question correctly (Smith et al. 2009).

The ability of students to solve new types of problems can also be improved by using this technique. Cortright, Collins, and DiCarlo (2005) investigated if a variation of Think-Pair-Share improved exercise physiology students' ability to solve new problems. Students worked in groups that contained up to four of their peers. The researchers divided these student groups into two main groups – groups that used peer instruction and groups that did not use peer instruction. Students in both groups listened to a short presentation on a specific topic. They were then asked to answer a question about that topic. All groups of students were given one minute to think about and record an answer to the question. Students in the peer instruction groups were also given one minute to discuss the answer to the question with each other and were allowed to change their answer based on what they learned from the discussion. Later students were given a unique problem to solve. Individual students were given up to 10 minutes to solve this problem. The results of this study showed that students who used peer instruction answered questions on the lesson correctly 59% of the time while students who did not use peer instruction answered these questions correctly 44% of the time ($p = 0.02$). The results also showed that students who used peer instruction could answer new problems correctly 47% of the time, while students who did not use peer instruction could only answer these problems correctly 24% of the time ($p = 0.04$) (Cortright et al. 2005).

Roe and DiCarlo's study on Think-Pair-Share (2000) investigated if the technique improved students' performance on short quizzes. Quiz questions were first differentiated into three different levels. Level one questions were the easiest and involved recalling material. Level two questions were more difficult than level one questions, and level three questions were the most difficult and involved evaluating material. Two-hundred and fifty 1^{st}-year medical students were then given short presentations on the respiratory system. After each presentation, the students were then given a one question, multiple choice quiz. Students were instructed to answer the question, discuss their answer with a partner, and then change their answer if they wanted. Answers to these questions were collected and assessed. The results showed that the percentage of correct answers from all levels increased after students discussed their answers with a partner. The percentage of level one questions answered correctly increased from 94.3% to 99.4%, level two increased from 82.5% to 99.1%, and level three questions increased from 73.1% to 99.8%. Paired t-tests used to compare the results all had a p-value below 0.05. The researchers concluded that Think-Pair-Share improves student performance on multiple-choice questions, and that the technique greatly improves student performance on higher-level questions (Roe and Dicarlo 2000).

In the present study, I chose to test the Think-Pair-Share peer instruction technique. Think-Pair-Share was chosen for testing because evidence from studies reviewed above have shown that it is effective in the classroom. Most of these studies were done in college classes, however, and I wanted to know if Think-Pair-Share would be effective in a high school setting. This technique was also easy to incorporate into my usual teaching method of giving students practice problems to work and then discussing the answers.

Materials and Methods

Due to Hurricane Isaac, which flooded East St. John High School and caused students to be out of school for almost a month, I was not able to carry out the study I had designed for the 2012-2013 school year. I instead used the data from a peer instruction trial collected during the 2011-2012 school year. These were collected as part of my normal classroom instruction. Original records these were destroyed in the flood and only de-identified records remained. Based on this information, Louisiana State University's Institutional Review Board approved my request for an exemption from student assent and parental consent (Appendix 1). The study was also approved by Mrs. P. Triche, principal of East St. John High School.

Study Population

The students involved in this study were academic-level chemistry students at East St. John High School. They were not grouped by grades, standardized test scores, or ability. School counselors randomly placed students who were required to take chemistry into classes based on scheduling needs. They were a mixture of 10^{th}, 11^{th} and 12^{th} graders who were either taking chemistry for the first time or repeating the course. My morning chemistry class was chosen as the control group. Twenty students were enrolled in this class. Seventy percent of these students were African-American, 25% where white, and 5% were Hispanic. I did not have any special education students in this class (Table 1). Twenty-five percent of the students were seniors repeating the course, and 75% were sophomores or juniors taking the course for the first time. The thirty-seven students in two afternoon chemistry classes were chosen as the experimental group. In these classes 76% of the students were African-American and 24% were white. There

were no special education students in my experimental group (Table 1).Nineteen percent of the students were seniors repeating the course and 81% were sophomores or juniors taking the class for the first time.

The racial makeup of my class was similar to the racial makeup of the school. The total population of the school consisted of 1,365 students. Of those 80% were African-American, 16% were white, 3% were Hispanic, and 1% were Asian/Indian. However, the number of special education students in my class was not reflective of the total school population, where 13% of students were classified as special education students (Table 1).

Table 1: Study Population

	School Population	Control Group Population	Experimental Group Population
Total Students	1,365	20	37
African-American	80%	70%	76%
White	16%	25%	24%
Hispanic	3%	5%	0%
Asian/Indian	1%	0%	0%
Special Education	13%	0%	0%

Subject Material

Instruction was focused on covering basic chemistry concepts including the scientific method, using the periodic table, balancing chemical equations, the mole concept, and basic

stoichiometry. The chapters that were incorporated into the study were “Introduction to Chemistry”, “Scientific Measurement”, and “Chemical Reactions” (Wilbraham et al. 2012). General chemistry terms and the scientific method were covered in “Introduction to Chemistry.” “Scientific Measurement” introduced basic chemistry problems, including significant figures, metric conversions, density, and dimensional analysis. Writing and balancing chemical equations were the basis for “Chemical Reactions.”

Study Design

The introductory chapter was taught using my usual classroom instruction methods (lecture from Powerpoint, notes, and hands-on activities) in both the control and experimental group. As part of instruction during the scientific measurement chapter students in both control and experimental groups were taught a Think-Pair-Share technique adapted from studies by Giuliodori, Lujan, and DiCarlo (2006) and Smith et al. (2009). When a new type of problem was introduced, one or two examples were worked for the students. Then the students were given a practice problem similar to the examples to work on their own. They were given between 1-5 minutes to solve the problem and then instructed to turn to a predetermined partner, discuss their answer, and correct it, if necessary. The time interval varied depending on the length and difficulty of the problem. The answer to the problem was then discussed with the entire class. Students repeated this process with another similar problem. I continued to use this method whenever I taught students how to solve problems.

When students were taught how to write and balance chemical equations, the control group was not instructed to use Think-Pair-Share. Examples and practice problems were worked independently. The experimental group used Think-Pair-Share to work examples and practice problems.

Assessment Methodology

Students were given a pre-test for each chapter involved in the study to gauge previous knowledge and a similar post-test to determine learning gains. Pre- and post-tests were treated as regular assignments. Pre-tests were used to introduce a new chapter, and post-tests were used to review the chapter after all material was taught. The questions on the post-test were the same as the questions on the pre-test but rearranged to prevent students from remembering the order of the answers. The average time between a pre-test and a post-test was seven to ten class days. As an incentive to take testing seriously, students were given bonus points for improvement from pre- to post-test. The questions on each pre- and post-test (Appendix 2) were drawn from the Pearson Exam View test bank (Wilbraham et al. 2012). Students did not have access to the answers to the pre-tests; however, answers to the post-tests were discussed in class after all students were done taking the test.

The students' results from the pre- and post-tests were paired up, and data from students who did not take both tests were excluded. The standard deviation was calculated for the tests for both the control and experimental group. Normalized learning gains, which are the percentage students improved from pre- to post-test, were calculated for each student by dividing each student's gain from pre-to post-test by their maximum possible gain. An average normalized learning gain was calculated for each group. Paired t-tests were used to compare the learning gains from pre- to post-test, the raw scores from the post-tests, and the average normalized learning gains for both groups. The p-value for statistically significant results was set at 0.05, the standard p-value for educational research (Mertler 2006).

Results

To determine if Think-Pair-Share improved students' performance in chemistry, the results from the control and the experimental groups were compared. Fourteen students in the control group (no use of Think-Pair-Share) took both the pre- and post-test (Figure 1). The average score on the pretest was 3.50 items correct out of a possible 12. The standard deviation for the pretest was 2.44. The average score on the post-test was 6.86 items correct out of 12. The standard deviation on the post-test was 2.74 (Table 2). Individual (Figure 2) and average normalized learning gains was calculated to determine how much students learned. The average learning gain for the control group was 38.5% (Table 2). A paired t-test used to compare the results of the pre- and post-tests had a p-value of 0.002.

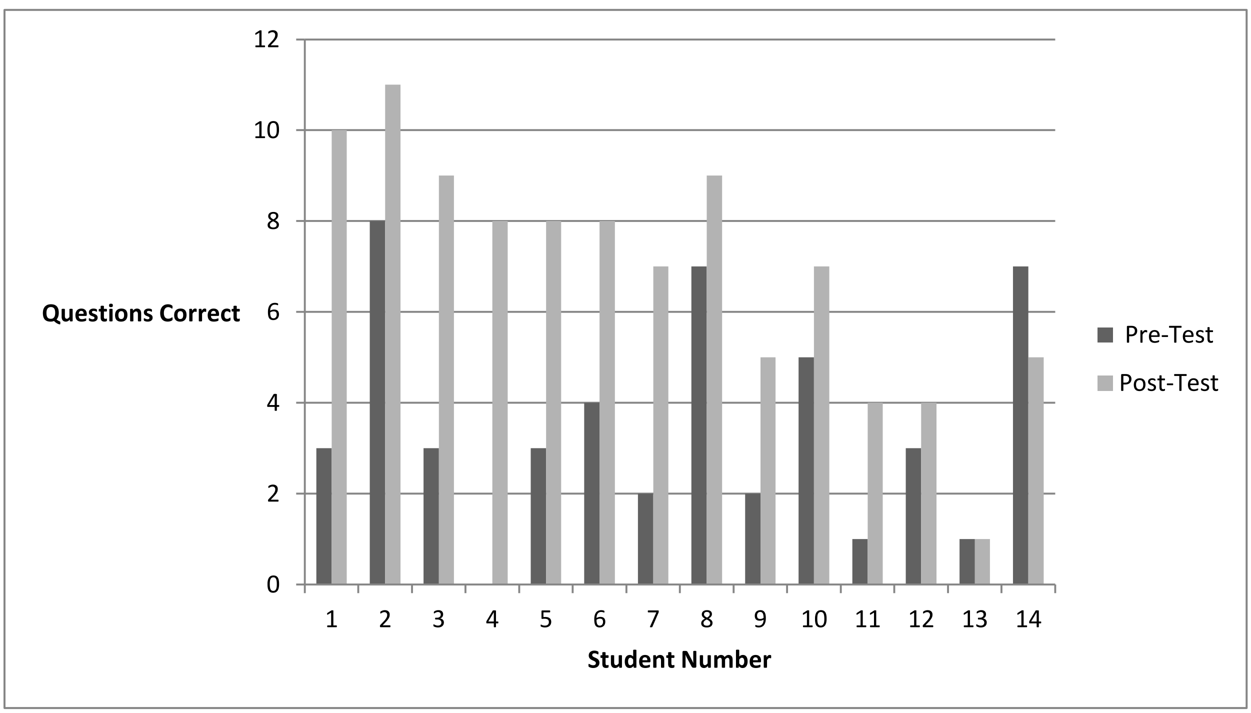

Figure 1: Control Group Pre-test and Post-test Results by Number Correct

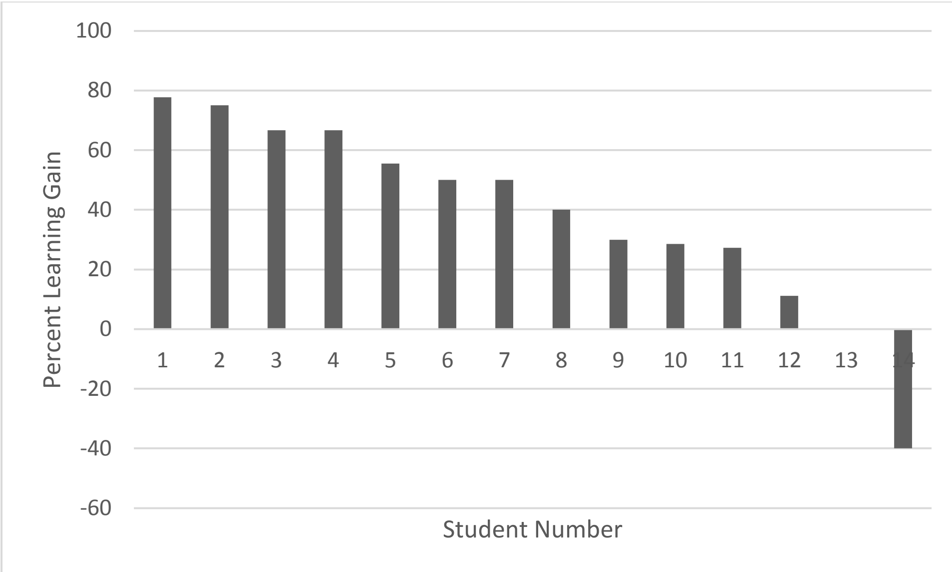

Figure 2: Control Group Individual Learning Gain (Average = 38.5%)

Table 2: Control Group Pre- and Post-test Data

	Average # Correct (out of 12)	Standard Deviation	Average Learning Gain
Pre-test	3.50	2.44	
Post-test	6.86	2.74	38.5%

Thirty two students in the experimental group (used Think-Pair-Share) took both the pre- and post-test (Figure 3). The average score on the pre-test was 3.88 items correct out of a possible 12. The standard deviation from the pre-test was 1.95. The average score on the post-test was 7.16 items correct out of 12. The standard deviation on the post-test was 2.64 (Table 3). Individual (Figure 4) and average normalized learning gains were calculated. The average learning gain for the experimental group was 38.8% (Table 3). A paired t-test used to compare

the results of the pre- and post-tests had a p-value of less than 0.001. There was a significant improvement in scores from pre- to post-test.

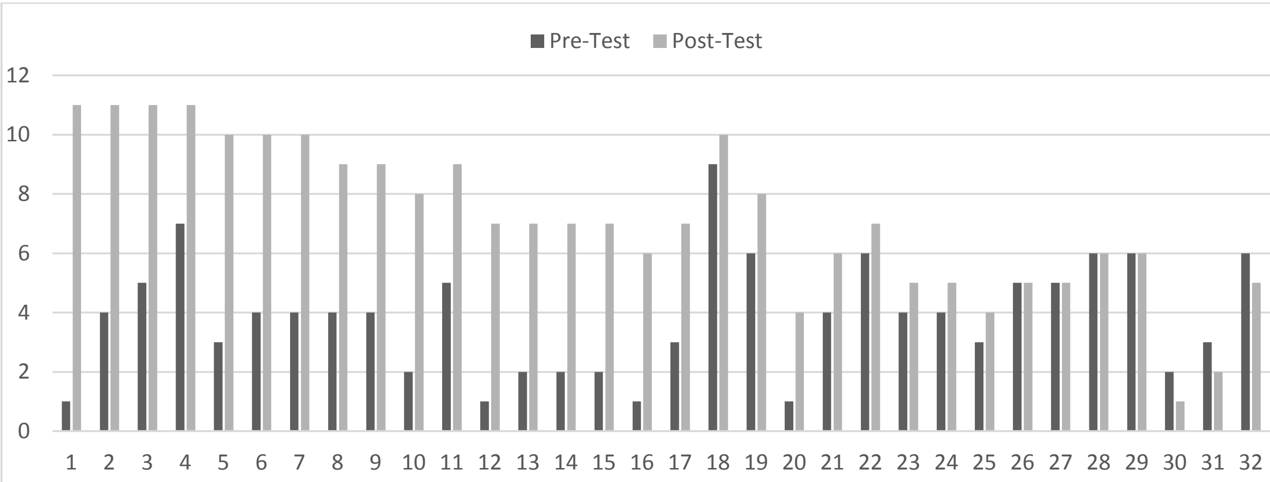

Figure 3: Experimental Group Pre- and Post-test Results by Number Correct

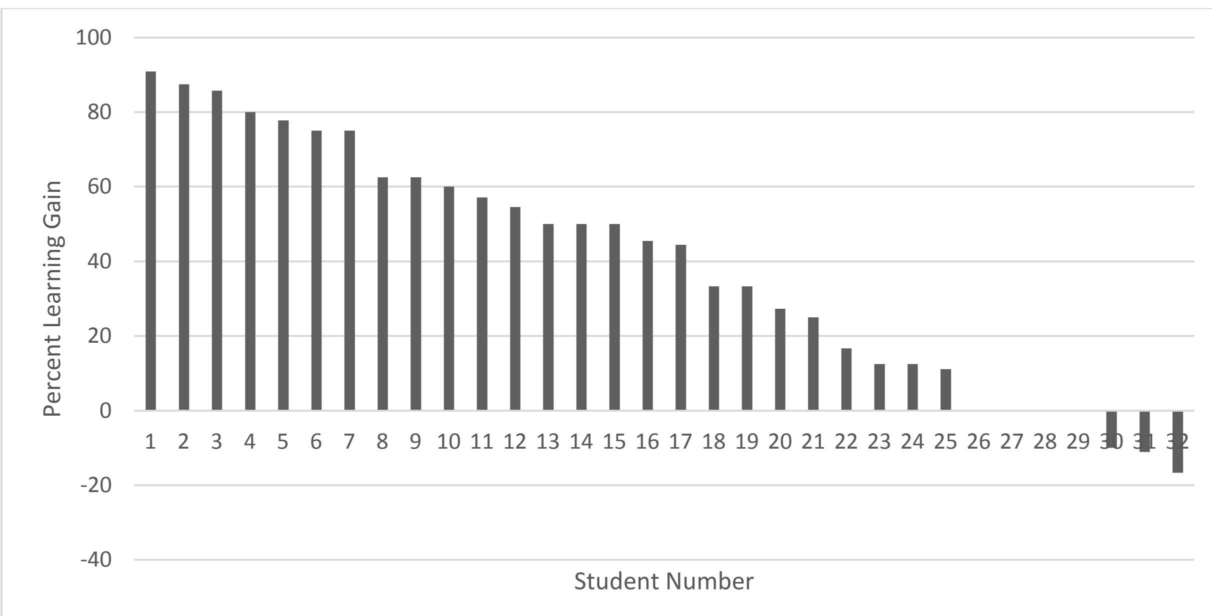

Figure 4: Experimental Group Individual Learning Gains (Average = 38.8%)

Table 3: Experimental Group Pre- and Post-test Data

	Average # Correct (out of 12)	Standard Deviation	Average Learning Gain
Pre-test	3.88	1.95	
Post-test	7.16	2.64	38.8%

Paired t-tests were used to compare the raw scores of both groups' pre- and post-test as well as the learning gains of both groups. The p-value of the t-test comparing the pre-test scores of both groups was 0.617. The p-value of the t-test comparing the post-test scores was 0.734 and the p-value of the t-test comparing the learning gains of the groups was 0.973 (Table 4).

Table 4: T-test Results of Comparisons between Control and Experimental Groups

	Pretest Raw Scores Control vs. Experimental	Posttest Raw Scores Control vs. Experimental	Learning Gain Control vs. Experimental
p-values	0.617	0.734	0.972

Discussion

Comparisons between the pre- and post-test of each group were significantly different ($p < 0.05$). This showed that students did improve their knowledge of the material taught. The post-test raw scores and the learning gains of both groups were not different ($p > 0.05$). Both groups showed a learning gain of 39%.

Although there were no significant differences in the instructional method used, Think-Pair-Share was at least as effective as my normal methods. There were several reasons for this. The first reason I believe I saw no difference between my control and my experimental groups was that my class sizes were small. I only taught three classes per semester, and my school tried to keep science classes to a maximum of 25 students whenever possible. The class I selected as my control group was my largest class, containing 20 students. I combined my two smaller classes for my experimental group which originally consisted of 37 students. Absenteeism also contributed to my small numbers. I excluded the results of six students from the control group and five students in the experimental group because they were absent for either the pre-test or the post-test. Because the classes discussed the results of the post-test after I collected all the papers, I did not allow students to make up the post-test.

My students also got so used to using Think-Pair-Share that they continued to use it when they were not formally instructed to do so. I did not tell my students in the control group to use Think-Pair-Share when I gave them equations to write and balance; however, I did not tell them they could not discuss their problems with a partner. Several students worked the problems and then automatically turned to someone sitting next to them to discuss their answer. I did not want to stop this interaction because it appeared to be helping the students learn how to balance

equations, especially the weaker students. I felt it would be wrong as a teacher to take away a technique that might be helping them learn.

Another factor that may have contributed to my results was the quality of the pre- and post-test questions. I used the Exam View test bank that was included in my textbook resources because, at the time, it was the only source of questions I had. I attempted to select questions that represented the material I was teaching, but my selection was limited. I added in questions that may have been too difficult for students just to make my pre- and post-test long enough to provide me with enough data to analyze. Other questions were poorly written or had ambiguous answer choices.

The study presented in this paper was designed to be a preliminary trial meant for me to practice using Think-Pair-Share in my classes and to refine my data collecting techniques. I was aware of many factors in this preliminary study that could have been improved upon and designed a new study taking them into account. The first factor was the size of my study population. To get as large a sample size as possible, I planned on using each class of chemistry I taught as both a control and experimental group. By combining the data from all three of my chemistry classes, I expected to have a relatively large group of 40 to 50 students. I would have taught the chapter on scientific measurement using only my normal classroom teaching techniques and then have students work practice and review problems on their own. This would have been my control group. My experimental group would have involved teaching the same three classes a similar chapter on stoichiometry in which I would have had students use Think-Pair-Share as they worked example and practice problems. This approach would have helped increase the study population but would have also introduced new variables. One of those variables was that the two chapters being compared were not identical, even though the material

taught in those chapters was similar. Differences in student learning could be attributed to the difference in chapters instead of the use of Think-Pair-Share. Alternating chapters with the control and experimental groups may have solved this problem but would have contributed to a different issue.

The second factor in my study that needed to be addressed was not preventing student interaction in the control group. Students in this group became proficient in using Think-Pair-Share and continued to use it even when not instructed to do so. To try and prevent that problem, I wanted to use a chapter taught in the first four weeks of instruction, “Scientific Measurement” (Wilbraham et al. 2012), as my control chapter. My reasoning was that because it was early in the school year, students would not know each other as well and be less likely to interact with each other. I also learned from the preliminary study that it is difficult to take away a technique from students who have gotten used to using it. I planned to keep a journal of student interactions so that I could have a basis for eliminating test results for students who worked together without my instructing them to.

I planned to address the issue of test questions by using the Eagle test bank, a bank of standardized test questions provided by the Louisiana Department of Education for use in preparing students for End-Of-Course testing. I gained access to this test bank the summer before I would have started my study and was able to create a pre-test and post-test for my control and experimental chapters. I felt that these questions were better at assessing the concepts I was going to teach than questions from the test bank that came with my book. The selection of questions provided by Eagle was small; however, and I still would have needed to use some questions from ExamView.

Another approach I could have used to obtain meaningful test questions was to analyze the results of each individual question on the original pre- and post-tests. This could be done by looking at the each question on the test and determining what percentage of students got it correct. A question being answered incorrectly by the majority of students could indicate that there was a problem with the question itself. I could then have used these results to design a new pre- and post-test with better questions. I also could have used the other chemistry classes I taught, honors and dual enrollment, to test out the questions before I used them on the pre- and post-test.

A collaborative study involving the other chemistry teachers in my cohort may have helped eliminate many of the variables in my individual study. If the five chemistry teachers in my cohort could have agreed on a specific teaching method to study, we could have combined the results from all of our classes. This would have eliminated the issues that came with small class size and absenteeism. We could have all evaluated the quality of questions and shared them with each other. This would have provided a tested bank of questions that we could have used for our pre- and post-tests. We could have even decided to use either morning or afternoon classes, eliminating one more variable from the study.

I was not able to conduct my planned study. On August 29, 2013 Hurricane Isaac struck Louisiana and caused severe flooding in several areas of Laplace and Reserve. East St. John high school received between five to eight inches of water in most buildings on campus. At least half of the student body and faculty suffered losses due to the storm. Students were out of school for almost a month, returning to a temporary campus on September 24, 2013. To accommodate all of our students on a smaller campus, the school day was broken up into two five-hour-long shifts. Approximately half of the student body was on each shift, either in the morning or in the

afternoon. Classes were shortened to less than an hour each, and students were rescheduled into new classes. The main focus in the semester that followed the storm was to get students settled into a normal routine and to help them overcome the trauma caused by the hurricane. Running an academic study under these conditions would not have been feasible.

In the future, when the situation at my school returns to normal, I plan to conduct my study as I originally intended. I believe that the data I would get from it would help convince other teachers that peer instruction is a valuable teaching technique. I would also like to conduct this study over a period of several years to compare the results from one group of students to the next. Through this process I have learned techniques required to be a good researcher as well as a good teacher. I plan on using these techniques in my role of teacher-leader at my school to assist other teachers with methods that will actively engage their students.

References

Common Core State Standards. Louisiana Department of Education, n.d. Web. 28 Mar. 2013 http://www.louisianabelieves.com/academics/common-core-state-standards .

Barkley, Elizabeth F., K. Patricia Cross, and Claire Howell. Major. *Collaborative Learning Techniques: A Handbook for College Faculty*. San Francisco: Jossey-Bass, 2005. Print.

Cortright, R. N., Heidi L. Collins, and Stephen E. DiCarlo. "Peer Instruction Enhanced Meaningful Learning: Ability to Solve Novel Problems." *AJP: Advances in Physiology Education* 29.2 (2005): 107-11. Print.

Crouch, Catherine H., Jessica Watkins, Adam F. Fagen, and Eric Mazur. "Peer Instruction: Engaging Students One-on-One, All at Once." *Reviews in Physics Education Research*. Ed. E. F. Redish and P. Cooney. College Park: American Association of Physics Teachers, 2007. N. pag. Print.

Doymus, Kemal. "Effects of a Cooperative Learning Strategy on Teaching and Learning Phases of Matter and One-Component Phase Diagrams." *Journal of Chemical Education* 84 (2007): 1857-860. Print.

Fagen, Adam P., Catherine H. Crouch, and Eric Mazur. "Peer Instruction: Results from a Range of Classrooms." *The Physics Teacher* 40.4 (2002): 206-09. Print.

Giuliodori, M. J., H. L. Lujan, and S. E. DiCarlo. "Peer Instruction Enhanced Student Performance on Qualitative Problem-solving Questions." *AJP: Advances in Physiology Education* 30.4 (2006): 168-73. Print.

Mazur, Eric. "Peer Instruction: Getting Students to Think in Class." *The Changing Role of Physics Departments in Modern Universities: Proceedings of International Conference on Undergraduate Physics Education, College Park, Maryland, August 1996*. Ed. E. F. Redish and J. S. Rigden. Woodbury, NY: American Institute of Physics, 1997. 981-88. Print.

Mertler, Craig A. *Action Research: Teachers as Researchers in the Classroom*. Thousand Oaks, CA: SAGE Publications, 2006. Print.

Noh, Taehee, Kyungmoon Jeon, and Douglas Huffman. "The Effects of Thinking Aloud Pair Problem Solving on High School Students' Chemistry Problem-Solving Performance and Verbal Interactions." *Journal of Chemical Education* 82.10 (2005): 1558. Print.

Rao, Sumangala P., and Stephen E. DiCarlo. "Peer Instruction Improves Performance on Quizzes." *Advances in Physiology Education* 24.1 (2000): 51-55. Print.

Smith, M. K., W. B. Wood, W. K. Adams, C. Wieman, J. K. Knight, N. Guild, and T. T. Su. "Why Peer Discussion Improves Student Performance on In-Class Concept Questions." *Science* 323 (2009): 122-24. Print.

Transition to PARCC Memo. Louisiana Department of Education, n.d. Web. 28 Mar. 2013 http://www.louisianabelieves.com/docs/assessment-transition/transition-to-parcc-memo.pdf?sfvrsn=6 .

Wilbraham, Antony C., Dennis D. Staley, Michael S. Matta, and Edward L. Waterman. *Pearson Chemistry*. Boston, MA: Pearson, 2012. Print.

Appendix 1

Application for Exemption from Institutional Oversight

LSU
Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

– Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-F, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://research.lsu.edu/CompliancePoliciesProcedures/InstitutionalReviewBoard%28IRB%29/item24737.html

– A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of parts B thru F.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtraining.com/users/login.php)
(F) IRB Security of Data Agreement: (http://research.lsu.edu/files/item26774.pdf)

1) Principal Investigator: Dr. John C. Larkin **Rank:** Professor

Dept: Biological Sciences **Ph:** 225-578-8552 **E-mail:** jlarkin@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each
*If student, please identify and name supervising professor in this space

Kathleen S. Trent - Graduate Student,LaMSTI MNS Program, Chemistry Teacher at East St. John High School, 985-479-2276, ktrent@stjohn.k12.la.us

IRB# E8028 LSU Proposal #______
✓ Complete Application
✓ Human Subjects Training

3) Project Title: The Effects of the Peer Instruction Technique "Think-Pair-Share" on Students' Performance in Chemistry

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 10/31/2015

4) Proposal? (yes or no) No **If Yes, LSU Proposal Number** ______

Also, if YES, either
◯ **This application completely matches the scope of work in the grant**
OR
◯ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) High school chemistry students

*Circle any **"vulnerable populations" to be used:** (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature [signature] **Date** 10/29/12 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted ____ Category/Paragraph 4a
Signed Consent Waived?: Yes / No
Reviewer Mathews **Signature** [signature] **Date** 11/1/12

Appendix 2

When potassium hydroxide and barium chloride react, potassium chloride and barium hydroxide are formed. The balanced equation for this reaction is ____.

a. $KH + BaCl \rightarrow KCl + BaH$
b. $KOH + BaCl \rightarrow KCl + BaOH$
c. $2KOH + BaCl_2 \rightarrow 2KCl + Ba(OH)_2$
d. $KOH + BaCl_2 \rightarrow KCl_2 + BaOH$

What is the balanced chemical equation for the reaction that takes place between bromine and sodium iodide?

a. $Br_2 + NaI \rightarrow NaBr_2 + I$
b. $Br_2 + 2NaI \rightarrow 2NaBr + I_2$
c. $Br + NaI_2 \rightarrow NaBrI_2$
d. $Br + NaI_2 \rightarrow NaBr + I_2$

Vita

Kathleen Sipos Trent is the daughter of Frank Sr. and Linda Sipos. She was born 1974 in New Orleans, Louisiana. She graduated from St. Charles Catholic in 1992. Kathleen attended Nicholls State University from 1992 – 1996, graduating cum laude in December of 1996 with a Bachelor's of Science degree. She entered Louisiana State University Graduate School in May of 2011. Kathleen currently teaches chemistry at East St. John High School in Reserve, Louisiana.