

HOW WILL STUDENT SCORES BE AFFECTED BY INCORPORATING PLAN, DO,
STUDY, ACT (PDSA) STRATEGIES IN THE CHEMISTRY CLASSROOM?

by

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ABSTRACT

This project examined the effectiveness of using a Plan, Do, Study, Act model in a Chemistry classroom to increase student scores. Plan, Do, Study, Act is a systematic method used in the classroom, involving the students in the planning and assessment of several Chemistry units. The classroom teacher and students spend time at the beginning of each unit planning how to study the material and then enact the plan. Frequent formative assessments are used to study how the plan is working and if adjustments are needed, the class will enact changes in the original plan. By examining the data collected with student surveys, exam scores and student interviews, it was found that this method of teaching increased the summative exam scores of the lower students, but not the class as a whole. I can conclude that by using Plan, Do, Study, Act in the classroom, the students at the bottom of the class gained a connection to the rest of the class, causing their performance to improve.

INTRODUCTION AND BACKGROUND

For my action research project, I wanted to try a systems approach to help open communication between my students and myself, by showing transparency in the planning process and using frequent formatives to help with retention of materials and increase study habits. I have observed from my Honors Chemistry classes that students tend to only study the day before the summative exam and have difficulty in retaining knowledge from one unit to another. Because of the difficulty of the material in chemistry, students tend to show a range of emotions, with frustration being the most common.

I teach at Sandra Day O'Connor High School, a public high school in the Deer Valley Unified School District in Phoenix, Arizona. It is a large school, with a population of 2451 students. Our population consists of students from upper socio-economic families, with very little ethnic diversity. Our student body consists of 88% Caucasians, 6% Asians, 3% Hispanic and the remaining 4% are a variety of races. Twelve percent of our students receive additional assistance from either an Individualized Education Program (IEP) or a 504 plan, and only 2% receive assistance with the free and reduced lunch system. 47% of our graduates attend a 4 year university while 32% attend a 2 year college program. Our school is one in which students can and will be successful if given the correct guidance. As a teacher at O'Connor High, I feel that by giving the students the tools that they need, they too can be just as successful as our past graduates.

A systems approach uses a multi-step process, with four of the steps being Plan, Do, Study and Act (PDSA). Plan, is collaboration between the teachers and the students on how to

teach, learn and reinforce the material within the unit of study. Do, is enacting the plan that the classroom previously agreed upon. Study, involves using formative assessments, usually frequently, to determine how the plan is working. Act, is to take the information from the formative assessments, and use it to adjust the plan, if needed. With PDSA, the goals are to include the students in planning the unit, using formative assessments frequently and sharing the results of both the formative and summative exams with your classes in a timely manner. Students are encouraged to participate in the feedback process, particularly by suggesting different methods and techniques of teaching the material. My hypothesis is that by incorporating the PDSA model in my Honors Chemistry classes, my students will experience less frustration and that there will be an overall increase in student scores.

The main question for this research project is: “How will student scores be affected by incorporating Plan, Do, Study, Act (PDSA) strategies in the chemistry classroom?”

Within the study of the above main question, I feel that the following sub questions can be answered as well:

1. “What is the effect of PDSA on student ownership of their progress in Chemistry?”
2. “What is the effect of PDSA on student achievement in the Chemistry classroom?”
3. “How does using PDSA help educators in monitoring student progress?”

It is the first sub question that I have explored with instruments that I normally do not use in the classroom. I collected data by using two different instruments, student surveys and student interviews. All students were given a survey before treatments begin and then post- treatment as well. I evaluated the survey information with a Likert scale, therefore, giving a numerical point system to the responses chosen from both students and parents alike. Student interviews were

also given at the beginning of the treatment and again at the end of the treatment. Thus, I was able to probe deeper into why they feel how they do about the class, the material in class and the PDSA cycles.

During this process, my support scaffolding has consisted of three individuals. Each of the members of my team has brought with them individual strengths. Mrs. Jody Evans and I have worked together as Science Department Chairs for the past 3 years. She is very insightful with using PDSA models and has implemented them in her classroom for the past 2 years. I feel that she has been a rock to lean on as I have placed these new methods into my teaching style. She has thoughtfully given me several suggestions on how to use a PDSA model.

Mrs. Alexis Fulton is a unique resource as she is certified in both biology and language arts. I used her constantly as a resource for proof-reading and in helping me express scientific ideas with writing flair. She understands the science methods behind my madness and can check my grammar as well.

Mr. Brian Stewart is my “outsider”. He has not used PDSA cycles, and he is not from a science field. However, he just completed his Master’s degree program and can relate to the process of collecting data and translating it into my research. His previous experiences will be valuable to me, and I have enjoyed having him look at my research with non-science eyes.

CONCEPTUAL FRAMEWORK

In looking at whether or not to pursue a research project in giving students more responsibility in the classroom, I wanted to see if these ideas were discussed before and also see

how other teachers have implemented similar strategies before me. I located several articles based on the concept that teaching should become a shared mission between educators and students. In implementation, it is vital that the students are in on the ground-level of the goal in mind. One of the challenges of adopting student-centered assessment strategies is students' misconception about what it is (Hewitt-Taylor, 2001). Too often, when a student-centered goal is in mind, the student can take a mindset that it will be as easy as they want to make it, or that the teacher doesn't know what they are doing, so they are trying to ask for help. It is key that the educator remains in the role of the facilitator and guides this process as much as possible.

Upon building a classroom based on a PDSA model, I also found that frequent cycles of reflection are also necessary for success. Reflecting on classroom practice helps to develop insights into the reasons behind our actions (Carr & Braunger, 1998). By incorporating frequent cycles, the instructor and the students can take the time to see if they are headed in the right direction; discuss what worked in the instruction and also plan ahead to make sure that the mutual goal in the classroom will be reached. In using PDSA in my study, I plan on using frequent feedback from my students into where we have been and in what direction we need to move in order to work towards mastery of knowledge.

Most of the theoretical research was based not on classrooms, but more in the business sector of society. Industry has been using PDSA cycles for over 60 years now. W. Edwards Deming introduced PDSA as a part of his systems methodology to business leaders in Japan during the 1950's (Fromberg, 2010). Deming's ideas were revolutionary at the time, inspiring companies such as Toyota to function as a whole group, not just a small group of managers dictating what should be done. He encouraged companies to look for solutions to whole

problems, to be pro-active and not just reactive to single negative events. Thus, all of the stakeholders within the organization were a part of the solution, providing a holistic quality to the organization.

Recently, there has been a push to use such cycles in the educational field as well. Of the articles I perused, most of them agreed, that to be done correctly, the implementation has to be done with persistence and with fidelity. Educators must put in the time to reach an acceptable level of success. If done properly, class development is a necessary prelude to deeper learning. Indeed, a greater danger is not spending enough time. Such under-preparation can cause frustration and disorientation among students who are accustomed to organized learning environments (Brush, 2001).

Changing how an educator views a classroom, can be a difficult process. Most teachers teach their students how they were taught, to some degree. I was successful in lecture based environments, so therefore, I tend to use a lecture based classroom. It can be stressful to step out of one's comfort zone and to try something new. However, to be able to change a classroom, there needs to be proof that it would work. Beliefs about learning and teaching should be justified through evidence supporting teachers' ideas (Richardson, 1994). I have found, through my colleagues that they believe PDSA cycles work. Just this knowledge alone, has given me enough courage to change out of my shell and try something new. But is it really a new method? With a little more searching, I found that educators have been looking at student-centered learning for quite some time. Student-centered learning environments are set up in such a way that they give students the chance to take the responsibility for organizing, analyzing and

synthesizing knowledge, and consequently play a more active role in their own learning (Means, 1994).

In the case of a classroom, a systems approach to continuous improvement helps us pay attention to the right parts (standards, instruction, assessment) and how all those parts work together to produce learning (Shipley, 2010). In using a continuous improvement classroom, there isn't very much data to show how important it must be. Shipley (2010) stated that "when all of the pieces are together, the classroom becomes a learning system and a systems approach to continuous improvement as the way teachers and their students work together to improve learning results"(p. 9).

It seems that most of the research shows using PDSA cycles will improve learning in the classroom by creating a cooperative environment to reach learning goals. Our job as teachers is to create the kind of learning system in which all of our students learn and demonstrate proficiency in all content and program areas – not just those tested annually by the state (Shipley, 2010). I feel that no matter what plan is enacted in the classroom, if it is done with fidelity, it will be successful. The translation of research results and successful science teaching and assessment for sustainability into action, is not only doable, but it should be done purposely and persistently (Zoller, 2011).

Most of the additional pieces that I found didn't necessarily have to do with Plan, Do, Study, Act, yet it dealt with being purposeful in changing the classroom environment. The time is ripe for this Low Order Cognitive Students-to-High Order Cognitive Students/from teaching-to-"know" to-learning-to-"think" shifts (Zoller, 2011). Educational changes are happening and it is important to lead the shift in the classroom. The shift towards having the students become an

active part in the classroom has led to an improvement in the learning process. Student-centered learning helps students to get their own goals for learning, and determine resources and activities guiding them to meet those goals (Land, 2000).

Plan, Do, Study, Act has been in place for well over 60 years, in most sectors of business. As of recently, it has been incorporated into the educational world. I feel that now is the time and place to become an improved educator and that using PDSA will facilitate that move for me. Transparency of how we are learning and why we are learning it is really what it all comes down to. What really counts is what students and teachers do in classrooms every day (Schalock, Tell, & Smith, 1997). My students should be learning more than facts and figures, they should be learning how to be at a higher level of thinking. Systems thinking motivated many great companies into becoming global giants, and I believe that it can be used to motivate our students into becoming global leaders as well.

METHODOLOGY

Treatment

In my current classroom the usual procedure for a unit includes lecture, practice problems, and a laboratory for the unit. These normal steps are then followed by a summative assessment. I have found that my units cycle in the same manner as we progress throughout the year, with very little variation as to how the information is given. I followed these treatment cycles during the implementation of my project. The 1st three units of fall semester 2012 were

conducted in the traditional method of lecture, practice problems, laboratory experiment and summative assessment.

The 5th unit, however, was presented in the Plan, Do, Study, Act (PDSA) model. The students were incorporated into the planning of the entire unit, starting with the first day. As a class, we reviewed the upcoming chapter in the book and discussed the skills and practices needed to master the material. The students were then asked to list three practices that they needed to use and they also listed, collectively, three methods that I, as the teacher, needed to incorporate into the lesson.

Their self-imposed practices included, reading the textbook at least twice during the unit, at home, completing their homework at least a day before it was due so that they could have the opportunity to ask questions, and asking questions right when they think of them, instead of waiting until it was too late. And that they needed to ask questions in class, right when they thought of them, instead waiting until it was too late.

They suggested that I, as the teacher, needed to use at least one formative assessment in each unit. Their second suggestion was that I should show more visuals in lecture, including graphs or diagrams, to help explain the concepts. Their third request was if I could create more examples that mirrored their homework problems. All of these practices were agreed upon by not only the class, but also by me, the teacher.

This list of six items was then posted at the front of the classroom. Thus, we could look at the list daily and affirm if all of the stakeholders in our classroom were completing our agreed upon practices. By collectively using the list of desired changes, it led to a transparent classroom, where a common goal was sought after daily.

After the 5th summative was complete, I switched back to the traditional lecture method, where I controlled the planning and execution of the unit. At the completion of the 6th unit, where I used the traditional method of teaching a unit, I switched back to a PDSA method for the 7th unit. Again, students were involved with planning and we used formative assessments to track our progress during the unit.

The timeline for data collection began on October 30, 2012, when we finished the 4th unit, which was a non-treatment unit. The students took a survey to give a baseline of their perception of chemistry. Unit 5 began on October 31, 2012 and was a treatment unit, meaning that we started with a PDSA cycle. The unit included a pre-test, instruction with a formative assessment and concluding with a summative assessment. At the beginning of the unit, student interviews were conducted, to gather more data about the use of the PDSA cycles. Student interviewees were selected with a stratified random sample, with 5 students picked from the bottom of my classes (below a 70% grade in class), 5 from the middle bottom (between a 70% & 80%), and 5 from the top middle (between an 80% & 90%) and 5 from the top (above a 90% grade in the class).

We started Unit 6 on November 15, 2012 as a non-treatment unit. The non-treatment did not have a PDSA cycle; however, we took a pre-test and took a summative exam. Unit 7 began on November 28, 2012, with a pre-test and a PDSA cycle. Instruction included a formative assessment and concluded with a summative assessment. Surveys were then administered to the students at the end of this treatment unit. Students were interviewed again, as a post treatment collection of data. The interviewees were the same cohort group, to keep a consistent group with which I could use the answers comparatively.

Table 1
Treatment Timeline

Date:	Unit Covered	Treatment or Non-Treatment	Data Collected
Fall 2012		Treatment	
10/31 – 11/14	Unit 5 (Periodicity)	Treatment	Student Survey, Student Interviews, Pre-Test, Formative & Summative
11/15 – 11/27	Unit 6 (Compounds)	Non-treatment	Pre-Test, Summative
11/28 – 12/5	Unit 7 (Writing Balanced Equations)	Treatment	Student Survey, Student Interviews, Pre-Test, Formative & Summative

Research Methods

My data samples have come from my three sections of Honors Chemistry, which consist of 100 students. Of these 100 students, 98% are sophomores (10th grade) and two percent (2%) are juniors (11th grade). Fifty-five percent of this sample are females, while 45% are males. Almost all of these students come from an upper socio-economic background, as evidenced by having only two percent (2%) of our student population (2451 students) qualify for free or reduced lunch. There are no students in this sample having an IEP or any help with a 504 plan

either. One of the students in the sample is an exchange student from Brazil, which would qualify him as an English Language Learner (ELL) student. However, he is the only ELL student in this sample size.

During my treatments, I collected data from all 100 of my Honors Chemistry students. Several collection tools were utilized to address my research questions (Table 2).

Table 2
Data Collection Methods

Research Questions	Interviews	Student Surveys	Pre-Test	Formative Assessment	Summative Assessment
I. How will student scores be affected by incorporating Plan, Do, Study, Act (PDSA) strategies in the chemistry classroom?			X	X	X
II. What is the effect of PDSA on student ownership of their progress in Chemistry?	X	X		X	X
III. What is the effect of PDSA on student achievement in the Chemistry classroom?"		X	X	X	X
IV. How does PDSA help educators in monitoring student progress?			X	X	X

At the beginning of each unit, my students took a pre-test, received course information and then they took a summative assessment at the end of each unit regardless of whether it was a treatment or non-treatment unit. An example of the Unit 5 pre/post test is shown in Appendix A. At the beginning of Unit 5, students participated in the planning of the unit and then took a student survey (Appendix B) to gather baseline data on their perception about Chemistry. I also selected 20 students and administered student interviews (Appendix C), for a baseline feeling about the class. During the treatment units, the students took a formative assessment (Appendix D) at the halfway point of the unit. The formative assessment was designed to give us, as a class, a temperature reading on how their mastery of the material was progressing. It also gave the class a chance to gauge how they were performing on their commitments to learning the material. At the end of Unit 5, students then completed the Unit 5 summative exam (Appendix A). Scores were then compiled on not only the surveys, but also the pre/post tests and the formative exam as well.

The student survey (Appendix B) was based on confidence in Chemistry/Science and how the students felt about the class and their study habits. Surveys were scored by using a Likert scoring system, giving a point value to each response on the survey. The point values were then tabulated for each survey and entered into a database.

Table 3
Likert Survey Scoring

Survey Choice	Likert Score
Strongly Agree	+2
Agree	+1
Neither Agree or Disagree	0
Disagree	-1
Strongly Disagree	-2

Student interviews were conducted again at the end of Unit 7, with the same cohort group that I had at the beginning of the treatment cycle. Interview responses were categorized by common responses and themes. This data was then triangulated with numerical data to support the sub-question posed in my research. By using the same cohort groups, I was able to ensure reliability with being able to collect data with a consistent student group. The surveys and interviews consisted of the same questions both times they were administered, lending to their validity within this study.

With the amount of data that was being collected, the principal at my High School, Dr. Bryce Anderson, agreed with the intent of the study and signed the Exemption Regarding Informed Consent form (Appendix F). The research methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained (Appendix E).

DATA ANALYSIS

If Plan, Do, Study, Act will truly create an impact in student learning, then the data I collected during my treatments should point to an affirmative. The main question for this research project is: “How will student scores be affected by incorporating Plan, Do, Study, Act (PDSA) strategies in the chemistry classroom?” After completing Unit 5 (treatment), Unit 6 (non-treatment) and then Unit 7 (treatment), students were given summative exams at the end of each unit, an example of which is in Appendix A. The data shows that summative exam scores did not change very much (Figure 1). All 3 summative exam averages fell within 8 percentage points of each other.

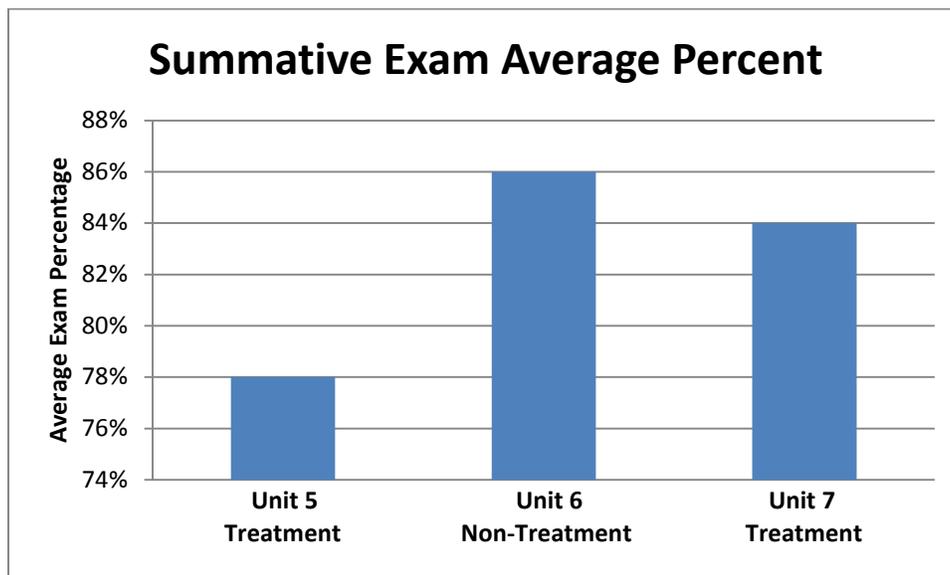


Figure 1: Average percentages on 3 summative exams, ($N=100$).

In fact, the summative exam scores were higher for the non-treatment unit (Unit 6), and then they were for the treatment units. However, when the average deviations were calculated for the same 3 exams, the data then shows that the treatment units caused all of the summative

scores to move up compared to the non-treatment units (Figure 2). By using deviation data, I can assume that the students were improving their skills enough that the lower scoring students were moving up towards the higher student scores.

All 3 units were comparable in difficulty for all of my students, with the factors of amount of material, difficulty of mathematical problems and the number of new vocabulary words, being compared across the units. Each unit consisted of an average of 35 textbook pages, with an average of 9 days of lecture for each unit as well. Unit 6 contained the most vocabulary words (27), however Units 5 & 7 each held 17 new words. Mathematical problems were at a minimum within all three units, giving a reasonable conclusion that the difficulty of the Units was even across the board.

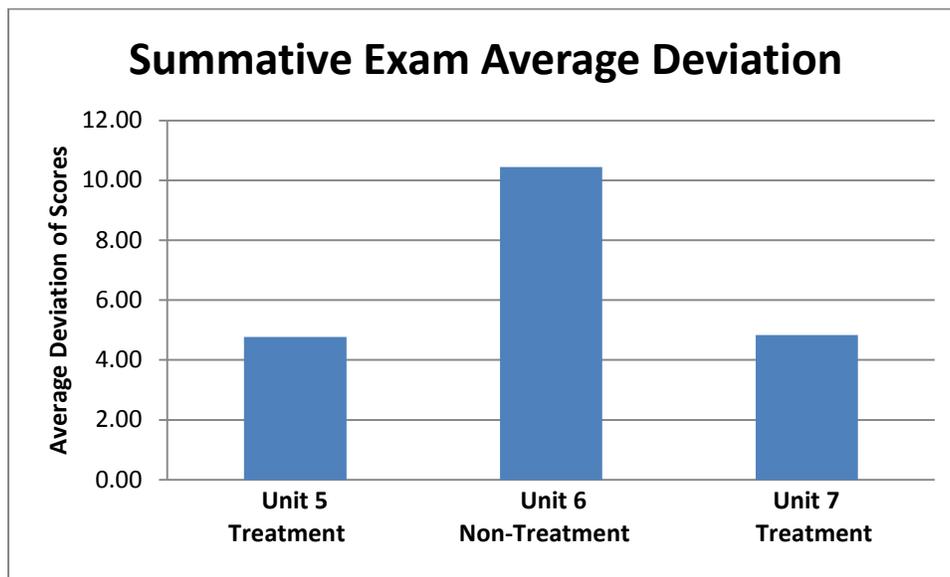


Figure 2: Average deviations on 3 summative exams, ($N=100$).

When deviation data was examined further, outliers were found as their scores were far below the average score on the exams. These outliers all showed a common tendency of not completing homework assignments or having difficulty in turning in laboratory assignments as

well. This fits with my experience as a teacher, completing homework and turning in assignments will correlate to improved test scores. However, upon further inspection, I also found that during treatment units, the outlier summative exam scores increased.

The outliers consisted of twelve students who were at the bottom of my study group. These 12 had been maintaining class average grades below 65% for the first 4 units of study. As a group, their tests scores averaged at 61%, with homework and laboratory scores being higher, therefore bringing their average scores just high enough to be passing the course. However, with the use of a PDSA cycle in Unit 5, these 12 had an average summative exam score of a 68% (Figure 3). With great interest, I found that during Unit 6 (non-treatment unit), these 12 students fell back to a summative exam average of 63% (Figure 3). Even more intriguing, was that their next summative exam average increased back to a 71% (Figure 3). The increase in their scores was in direct correlation with whether or not a PDSA treatment was being used in class. The data collected on the bottom twelve students fits with the trends seen as a whole group as well.

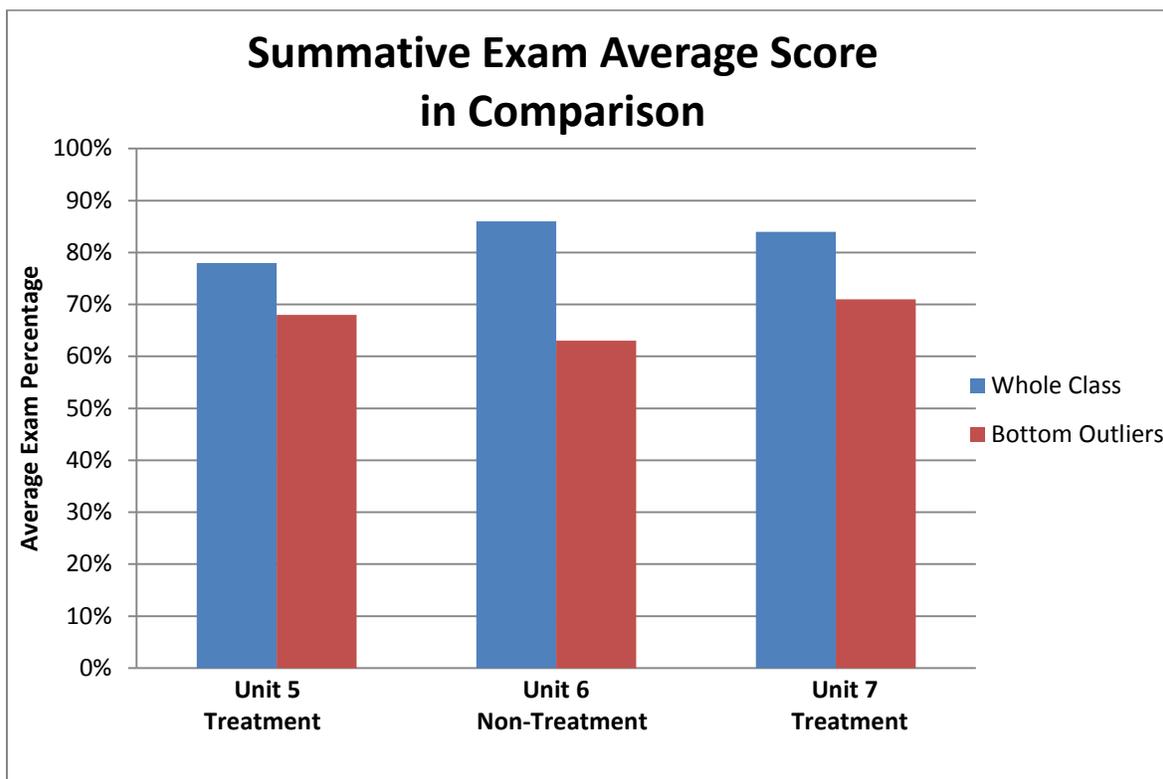


Figure 3: Summative exam average comparison, ($N=100$, $N=12$).

The main question led to a sub-question of “What is the effect of PDSA on student ownership of their progress in Chemistry?” An initial student survey was given after 4 units of traditional teaching. The survey (Appendix B) was used to see how the students felt about their participation in the class. When the results were analyzed, the average score on the initial student survey was at a 3/13 (Figure 4), based on a Likert Survey Scoring Scale (Table 1). The subjects were then given the survey again, at the end of the last treatment unit, and the average score on the final student survey was a 7/13 (Figure 4).

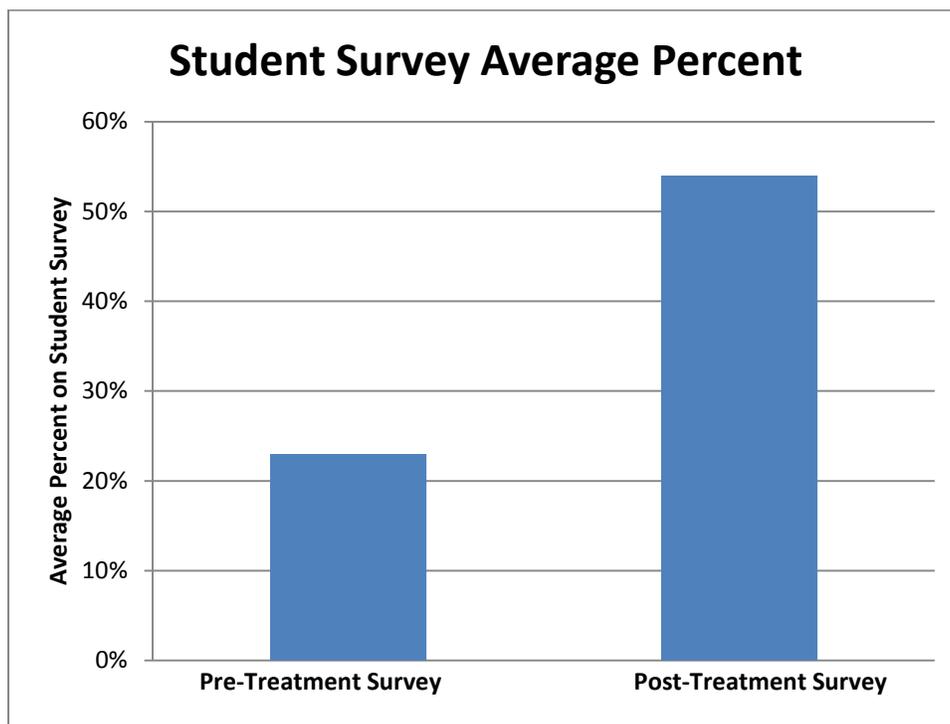


Figure 4: Student survey average percent, ($N=100$).

I felt that the student survey gave a great snapshot of how the class feels about their involvement in deciding how they learn concepts in Chemistry. With a traditional method of teaching, the survey data points to an inference that the majority of students do not feel connected with how their education is planned or that they have any say in determining their next course of action in the class. This inference would fit with a traditional method, as in which the students would not be involved in how each unit is planned.

However, when the last student survey was taken, the average score on the survey increased by 30%, showing a definite increase in student perception of their involvement in the class. But more importantly, the average deviation stayed at a point where all of the scores were still within $2\frac{1}{2}$ points of each other (Figure 5). By having such a small average deviation, I can

tell that the class is feeling relatively the same about how well using PDSA methods were working in the classroom.

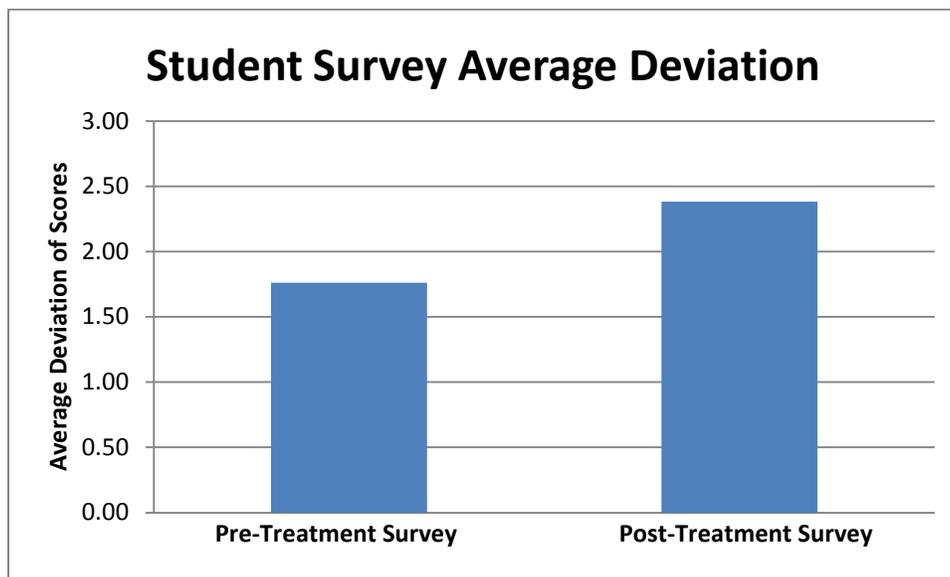


Figure 5: Student survey average deviation, ($N=100$).

I found that by looking at the average deviation (Figure 5), it shows how close most of the scores of the sample fall to each other. Student surveys had scores which were scattered across the board and it shows with the average deviation. However, the formative assessment from Unit 5 shows that as a large sample, most of the students had closed any gaps with each other (Figure 8). The techniques in class must be improving their knowledge of the subject, as most students were scoring close to each other.

The student survey addressed a question of ownership with “I feel that I have control over my grade and progress in Honors Chemistry” (Appendix B, Question #8). As our class progressed through the units of treatment, the responses to this question shifted in a positive manner, showing that their ownership of the material was increasing (Figure 6). Over 85% ($N=100$) responded positively in claiming that they alone were responsible for their grade. This

was a dramatic increase in ownership, as before the treatments were conducted, only 36% of the students felt that they had the sole responsibility.

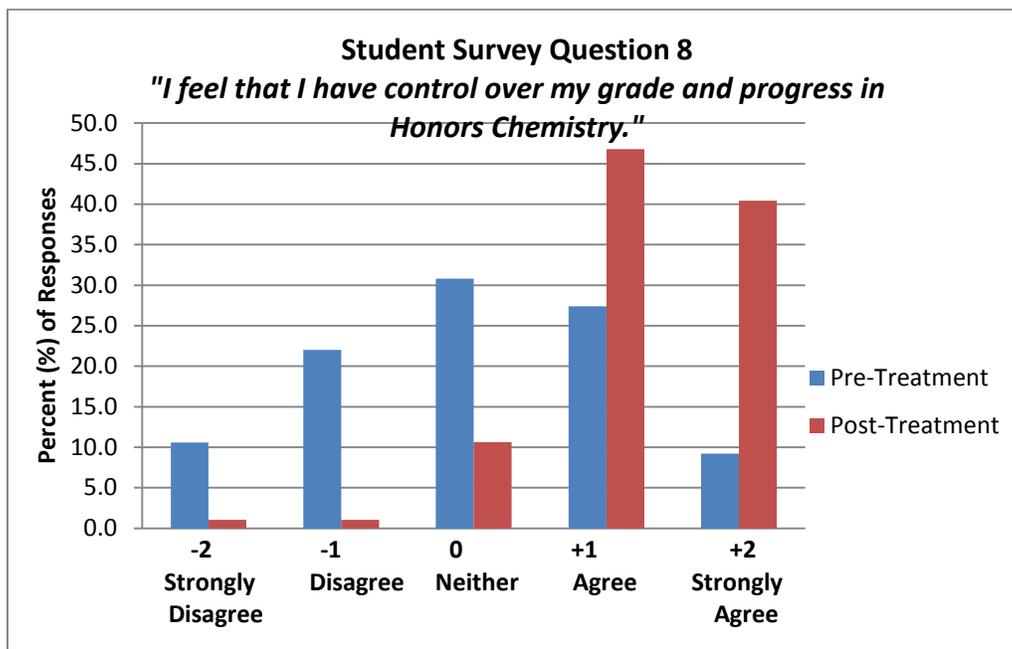


Figure 6: Percent of responses on question 8 of student survey, ($N=100$).

“What is the effect of PDSA on student achievement in the Chemistry classroom?”

Based on overall average scores, the data shows (Figure 7) that student achievement did not improve in the classroom by using the PDSA treatment. However, the average score did not decrease, therefore the use of the treatment seems to not have an effect on the overall achievement of my students, with the exception that the lower achieving students improved their scores, (Figure 2). I would like to infer that while using PDSA did not increase the average scores on the summative exams, it did bring the scores of my lower achieving students closer to the average.

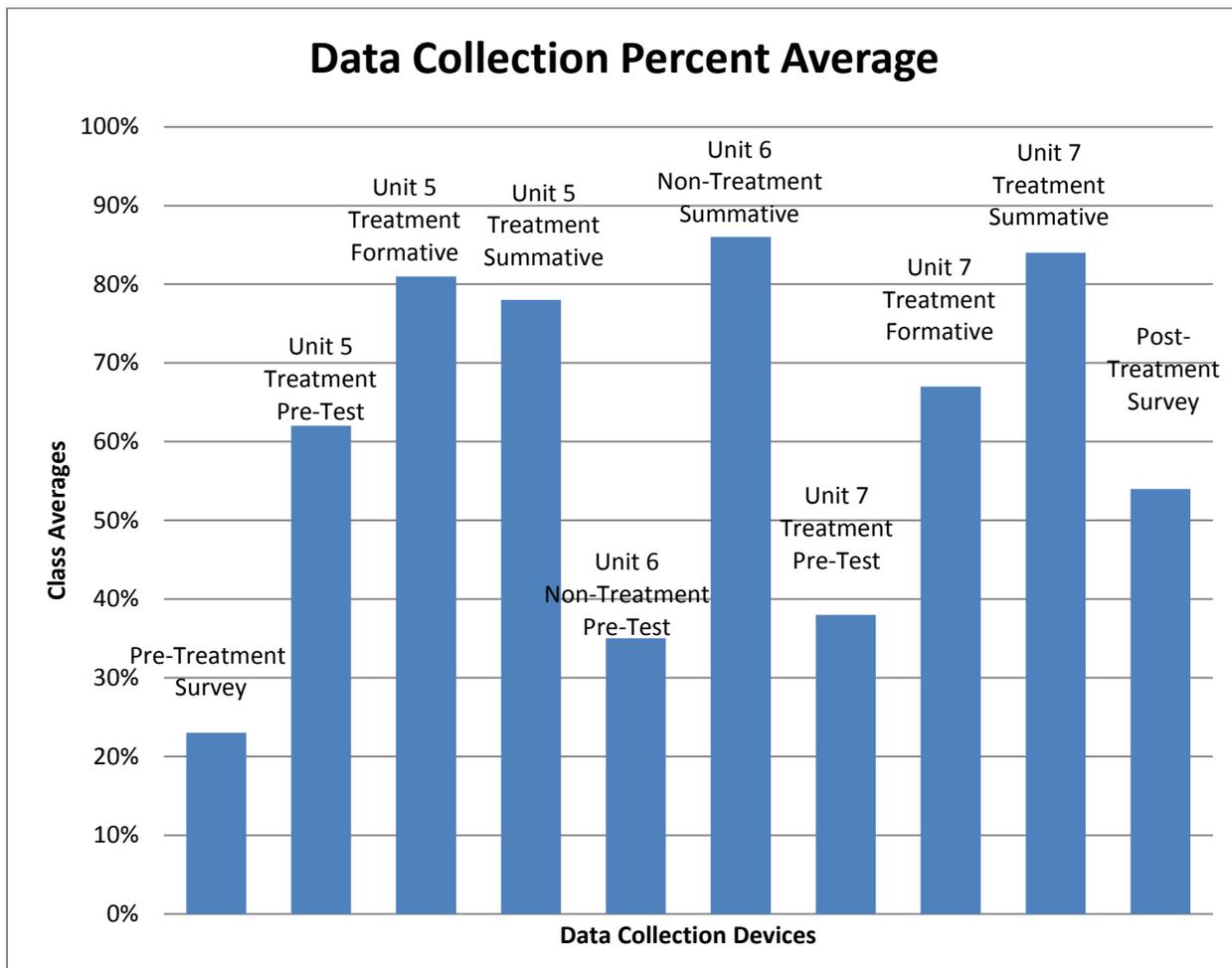


Figure 7: Average percentages on 10 data collections, ($N=100$).

Pre-test scores fell where I would have expected them too. Eighty-two percent of the sample size ($N=100$) scored at a 60% or less on each pre-test (Figure 7). It seems that every unit in chemistry is new material for most students, as it is not studied very extensively until they reach my class. Grade schools and middle schools are not introducing complex chemistry ideas; therefore, having an average of 60% is what I would normally expect.

More importantly, I have found in the average deviations, that with the use of PDSA as a treatment, student scores became closer together on the summative exams for treatment units. Granted the average percentages did not really change from non-treatment units, but by having

scores closer together, the data encourages that the students were using the new treatment to their advantage. At first, I was concerned that maybe the upper scores had decreased, but upon further review, I found that it was the lower scores which had increased. In Unit 6 (non-treatment), the average deviation was dramatically higher, giving an impression that by not using PDSA, the class fell further apart from each other, having wider gaps between scores.

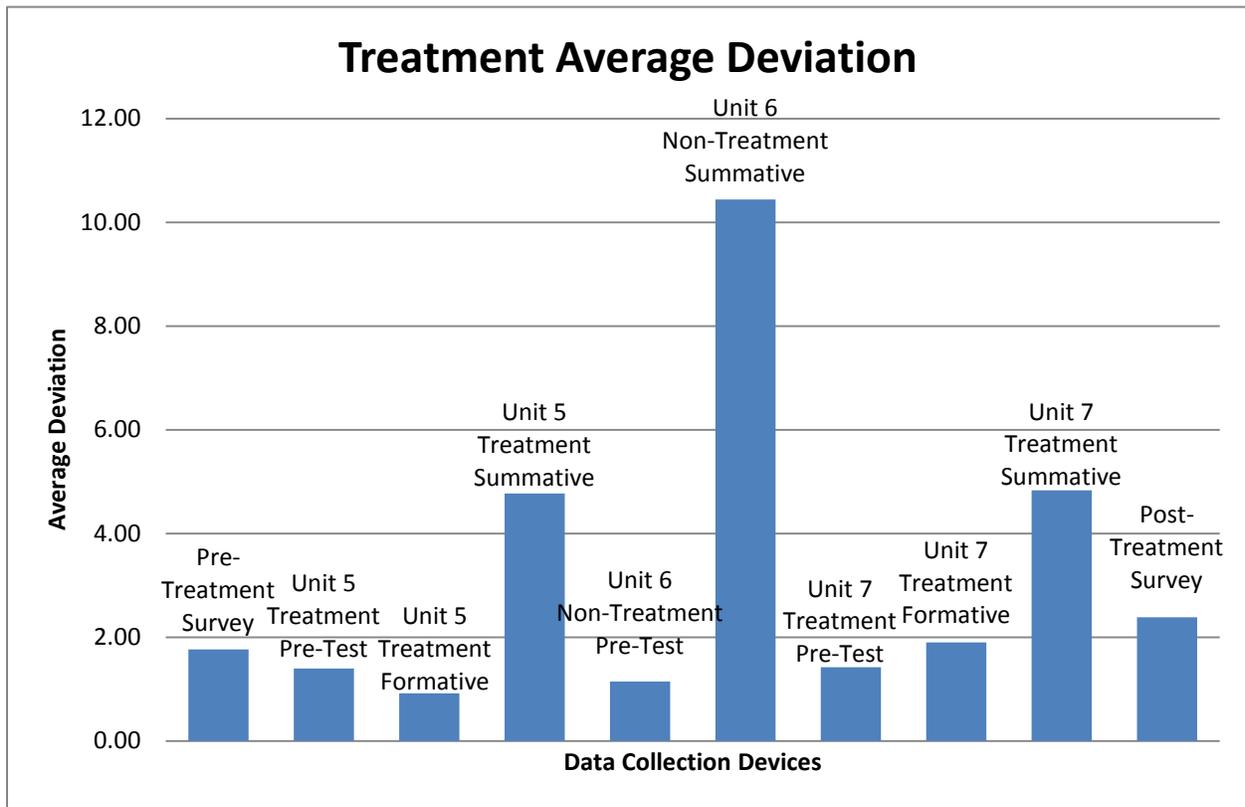


Figure 8: Average deviation of 10 collections, (N=100).

In conducting student interviews, responses were favorable towards the use of formative assessments. 95% (N=20) of the interviewees stated that it was very helpful to have a “look at what the exam would look like” before the summative exam. Of those 20 interviewed, 75% (N=20) also answered that they used the formative to scaffold how they would study for the summative as well. Only 20% (N=20) felt that “using PDSA helped when we could plan how

we should study material.” When asked if using PDSA made the class easier, 65% (N=20) answered that “it did, but only because of the formative exams.”

Based on the interview responses, I can see that using PDSA is helpful. The use of formative exams was correlated to an increase in their involvement in the classroom, at least in the students’ minds. Informally, sub-groups within my 3 sections of my Honors Chemistry classes told me that they felt the planning portion was a waste of class time. “We would rather just have you tell us what to do, rather than spend 20 minutes discussing what you would have told us anyway.” However, these were outliers as the main feeling found during student interviews was that the 20 students in the interview cohort group wanted the planning portion as much as the rest of a PDSA cycle.

“How does using PDSA help educators in monitoring student progress?” The answer to this sub-question is shown by looking at the average scores of the formative exams (Figure 7). As mentioned previously, students appreciated having the opportunity to practice their skills on the formative exam, while data shows that scores on a formative exam can give an indicator on how the students will perform on the summative exam. As an educator, I found myself looking at the performance on the formative exam to judge whether or not the class was ready to move on or to take the summative exam. By using formative exams, I found a tool that could give indication as to whether or not I should review a concept or move forward within the curriculum.

The student interviews also revealed that by having a voice in the class planning process, it gave them an opportunity to share their concerns with their progress in learning the material. When asked “*Are your suggestions listened to or acknowledged?*” the responses followed a general theme of, not only with an affirmative answer of yes (80% (N=20) were

positive), but with genuine surprise as well. “Mr. Lannen’s class is the only class where we can give our thoughts and he actually listens.” Or “I feel that what I have to say, is heard by Mr. Lannen. He seems to care about what we have to say.” By using Plan, Do, Study, Act in a Chemistry classroom, the data shows that the experience of taking chemistry, was improved for the student. Not only was there an improvement with their personal experience, but including improvement in the grades of the student whom wouldn’t normally score as well in the class.

INTREPRETATION AND CONCLUSION

Chemistry material has always presented a challenge to most high school students. The course contains difficult concepts and requires most to retain knowledge for the entire year. It is not an easy task to navigate through the class, however, with the appropriate tools, the experience can become more manageable.

“How will student scores be affected by incorporating Plan, Do, Study, Act (PDSA) strategies in the chemistry classroom?” Data analysis has shown that by using PDSA, student scores improve in the classroom (Figure 1), particularly by the end of the treatment/non-treatment cycle, where average summative exam scores increased by 6% from Unit 5 to Unit 7. I feel that by bringing up the bottom averages on summative exams, students are increasing their Chemistry knowledge and improving their perspective on the class as well. By using PDSA, the students with the lowest ability in class, improved the most (Figure 3). Traditionally, the mention of Chemistry would bring thoughts of fear and anxiety to most students. But based on a

greater than 30% increase on the student survey average, PDSA has brought the students a new outlook on the material and how the class can become less intimidating.

“What is the effect of PDSA on student ownership of their progress in Chemistry?”

Student ownership increased during the use of PDSA as well. Survey data and interview responses show that the students felt that they had control over their learning (Figure 6), and that this feeling increased by allowing the students to join in with the planning process. By having the innate feeling of being a part of something larger than just an individual, the individual tends to perform better. I would predict that this new attitude would lead to a greater performance by the class, as a whole. Once the entire class can buy in to an idea or system, the results can be without limit.

“What is the effect of PDSA on student achievement in the Chemistry classroom?”

Student achievement increased as evidenced by 6 point decrease (Figure 8) in the average deviation of treatment scores vs. non-treatment scores on summative exams. Achievement also increased in the bottom outliers of the class, showing a 5% to 8% (Figure 3) increase in their scores on the summative exams was well. The use of Plan, Do, Study, Act affirmed that an increase in achievement is possible.

“How does using PDSA help educators in monitoring student progress?” The use of a consistent, formative exam system, will provide the feedback necessary for an educator to monitor how the class is retaining and using information given. I found that by having such a check in place, gave me a window to gaze into my students’ ability and that it enabled me to adjust my instruction. When a consistent tool is used, it can be invaluable in the classroom.

By incorporating a PDSA model into my classroom, I have seen that my students have responded positively to having a say in what happens in their educational process. How long would this student attitude persist? As a 16 year veteran in teaching, I also know that not a single method is a fix-all for any classroom. Using a PDSA method is like any “new” method of the past, and by implementing it, a classroom does not instantly change.

One piece that I am still uncertain about is how can the use of PDSA help improve student retention of material? This question is one which I had initially planned on including within this study, but found that only collecting data for three Units made it a difficult one to answer. I would like to see data collection continue for an entire school year, with retention being measured throughout the year.

My original hypothesis stated that by using Plan, Do, Study, Act all scores would improve in my Chemistry classroom. However, I can conclude now, that this hypothesis was incorrect. Upon analysis of my collected data, I can now restate the hypothesis to say that by implementing Plan, Do, Study, Act in a Chemistry classroom, the scores of the lower performing students will increase. Using Plan, Do, Study, Act in the classroom gives both the teacher and the student a new perspective on how the transfer of knowledge and the process of an education can work. Student-centered learning is not a new process, yet in a new package, it still inspires new methods of expressing knowledge.

VALUE

After the completion of my project, I would still like to continue using PDSA cycles in my classroom. I feel that with the use of frequent formatives and being transparent with my students, I should be able to get a greater number of students to increase their grades in my classroom (Figure 3). My classroom data collection on the student survey (Figure 4) also shows that the students' perception of Chemistry improved as well.

With using transparent planning and formative exams, I was able to reach the students that normally make up the bottom of my class. Those students seemed to change their attitudes (Figure 6) the most about their education and put forth more effort than I have seen in quite some time from that group. By doing so, they not only helped the class averages (Figure 7), but also made the classroom a more engaging classroom as well. In the future, I plan on continuing to use the PDSA model if only just to bring up the bottom group. My classes benefited from having the opportunity to be open and transparent during our planning time. I plan on continuing the planning process, as well as using formative exams frequently. Not only did I have the opportunity to see if the class was ready for the summative exam, but by having formative exams, it gave the students that same opportunity.

This opportunity seemed to work for my students as well; it gave them the chance to see if they were ready for the summative exam. By allowing such a temperature reading of their readiness caused a change in their attitudes about the course (Figure 6). This change of attitudes, carried through to the rest of the class, making teaching even more exciting than it was before. If

that can happen in my classroom, I would like to encourage other teachers in my district to implement PDSA into their classrooms.

The knowledge that I have gained from this project will be put to use as I plan on presenting this information at our District-wide Chemistry Level meeting in February, 2014. On this day, all of the Chemistry teachers at our District will meet to discuss our classes, sequence of material, final exams, etc. I plan on presenting my findings from this research project to the group. The findings from using PDSA in a Chemistry classroom could be beneficial to these peer teachers.

In addition to presenting to my district peers, I would also like to present this to my high school's administration team, our Principal and his 3 Assistant Principals. There has been such a large shift in education to collect data and use it to drive our instruction, that I feel that this study could possibly help our school determine a future course of action. Plan, Do, Study, Act could become a tool for all of the educators on our campus, all 107 of them. With their approval, I would also like to post this study on our school website. If we can begin an initiation of using PDSA at O'Connor High School, it would be beneficial to present this data to our major stakeholders, our parents.

My students gained responsibility for their grades (Figure 6) and as I mentioned at the beginning of the paper, this shift would be immensely important to our school. If by using PDSA, we could somehow change the entitlement attitude on campus, then our campus could start moving forward into producing 21st century thinkers and college ready graduates. PDSA just might be the tool needed to become a world-class high school.

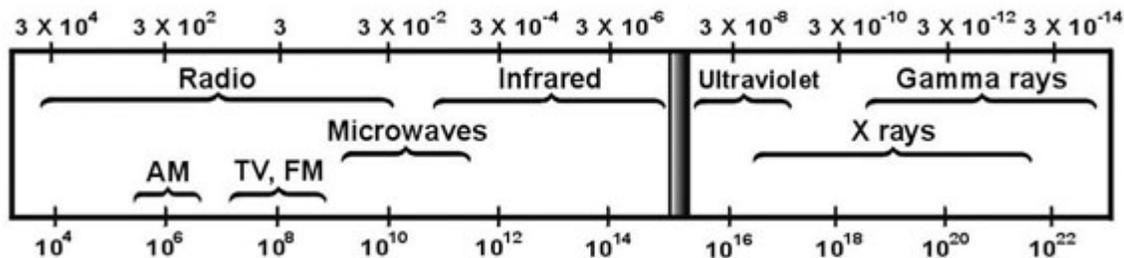
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APPENDICES

APPENDIX A

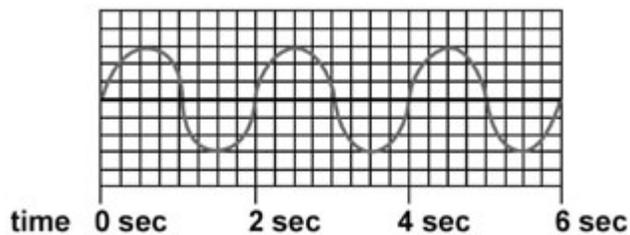
UNIT 5 SUMMATIVE EXAM



- ___ 6. Which type of wave has a frequency of approximately 10^8 hertz?
- AM radio
 - ultraviolet light
 - X-rays
 - TV, FM Radio, Cell phone

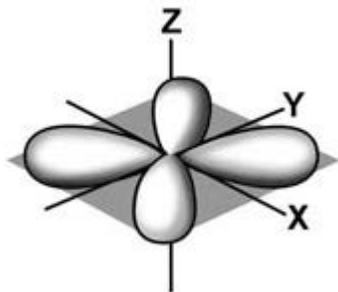
- ___ 7. Which type of wave has a wavelength of approximately 10^{-12} meters?
- microwaves
 - ultraviolet light
 - Gamma rays
 - AM radio

- ___ 8. Which is the frequency of the wave shown?



- 2 Hz
- 0.5 Hz
- 2 sec
- 3λ

- ___ 9. Which type of orbital is shown?



- s
- p
- d
- f

- ___ 10. Which is the correct number of valence electrons in the element Gallium (Ga)?
- 13
 - 1

b. 31

d. 3

____ 11. Which is the correct number of valence electrons in the element Sulfur (S)?

a. 16

c. 2

b. 6

d. 4

____ 12. Which element has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$?

a. Titanium (Ti)

c. Sulfur (S)

b. Chromium (Cr)

d. Selenium (Se)

____ 13. Which is the correct electron configuration for the element Molybdenum (Mo)?

a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$ c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^{10} 4p^6 5s^2 5d^4$ b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^6$ d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^4$

____ 14. Which of these elements has 5 valence electrons?

a. Boron (B)

c. Vanadium (V)

b. Rubidium (Rb)

d. Arsenic (As)

____ 15. Which is the correct electron dot diagram for the element Silicon (Si)?



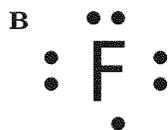
a.

c.

b.

d.

____ 16. Which is the correct electron dot structure for the element Fluorine (F)?



a.

c.

b.

d.

____ 17. Use Planck's constant, 6.626×10^{-34} , to solve the following:

What is the amount of energy carried by a photon that has a frequency of 5.71×10^{14} Hz?

a. 525 nm

c. 1.14×10^{-8} Jb. 3.78×10^{-19} Jd. 8.62×10^{47} J/s

____ 18. What is the frequency of a light wave with a wavelength of 680 nm?

a. 2.04×10^9 Hzc. 2.27×10^{-15} Hz

b. 2.04 s

d. 4.41×10^{14} Hz

____ 19. A photon is emitted from an atom with an energy of 4.25×10^{-19} J. What is the wavelength of the photon?

a. 467 nm

c. 1.28×10^{-10} mb. 2.73×10^{-4} md. 6.42×10^{14} m

____ 20. What is the frequency range for X rays?

a. 10^6 Hzc. 10^{14} Hzb. 10^8 Hzd. 10^{18} Hz

____ 21. How many valence electrons are present in silicon?

a. One

c. Four

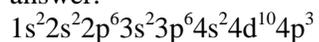
b. Two

d. Six

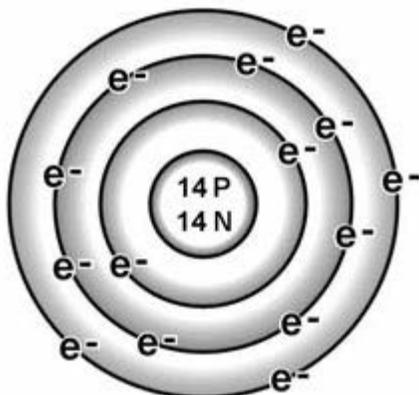
Short Answer

22. Predict how the wavelength and frequency of a wave would change if the amount of energy it carried was increased.

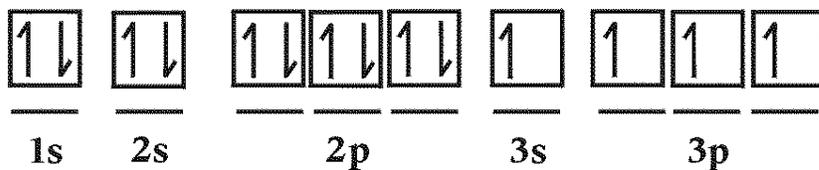
23. A student records the following electron configuration for the element Arsenic (As). Evaluate this student's answer.



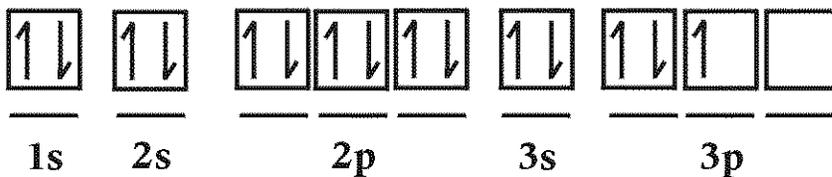
24. Use the model of the atom shown to identify the correct element. Write the electron configuration and orbital diagram for this element.



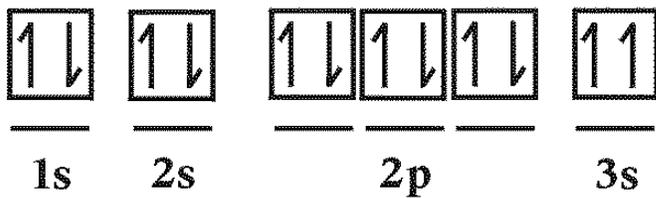
25. Which rule for filling of orbitals by electrons in the element Silicon is being violated in the orbital diagram shown? Draw the correct orbital diagram.



26. Which rule for the filling of orbitals in the element Phosphorus is being violated in the orbital diagram shown? Draw the correct orbital diagram.



27. Which rule for the filling of orbitals by electrons in the element Magnesium is being violated?



28. Explain what is wrong with this electron dot diagram for the element Nitrogen (N).



29. Why is it impossible to measure both the position and the velocity of an electron at the same time with accuracy?

30. What is the ground state electron configuration of chlorine(write it out)? Draw the correct dot diagram for chlorine.

Problem

31. A radiostation broadcasts a program at 122.9 MHz. Calculate the wavelength of the radiowave at this frequency.
32. Calculate the energies of two radiations. The first radiation is of wavelength 419 nm and the second is of wavelength 614 nm. The value of Planck's constant is 6.626×10^{-34} J.s.

APPENDIX B

STUDENT SURVEY EXAMPLE

STUDENT SURVEY

Name: _____

This survey is intended to be used as a data collection method for Mr. Lannen and for use in his completion of a Master's Degree from Montana State University. Participation in this survey is voluntary and participation or non-participation will not affect the student's grade or class standing in anyway.

1. Chemistry lectures provide enough information that I can be successful in the class without using outside help.
 - a. Strongly Agree
 - b. Agree
 - c. Neither agree nor disagree
 - d. Disagree
 - e. Strongly Disagree

2. As a Chemistry student, I feel that I have a say in how we are learning in the classroom.
 - a. Strongly Agree
 - b. Agree
 - c. Neither agree nor disagree
 - d. Disagree
 - e. Strongly DisagreePlease explain your answer.

3. I study Chemistry material (work on homework, labs or reading notes) _____.
 - a. Most days
 - b. Some days
 - c. Occasionally
 - d. Rarely

4. How much time, out of school, do you spend working on Chemistry related items every week?
 - a. Less than 1 hour
 - b. 1-2 hours

- c. 3-4 hours
 - d. More than 6 hours
5. I enjoy learning about science.
- a. Strongly Agree
 - b. Agree
 - c. Neither agree or disagree
 - d. Disagree
 - e. Strongly Disagree

Can you name two things you especially enjoy learning about?

6. I know that there is a direct relationship between how much time I study and my grade in Chemistry.
- a. Strongly Agree
 - b. Agree
 - c. Neither agree or disagree
 - d. Disagree
 - e. Strongly Disagree
7. Honors Chemistry frequently brings about feelings of frustration.
- a. Strongly Agree
 - b. Agree
 - c. Neither agree or disagree
 - d. Disagree
 - e. Strongly Disagree
8. I feel that I have control over my grade and progress in Honors Chemistry.
- a. Strongly Agree
 - b. Agree
 - c. Neither agree or disagree
 - d. Disagree
 - e. Strongly Disagree

Why did you answer the way you did?

APPENDIX C

STUDENT INTERVIEW EXAMPLE

STUDENT INTERVIEW

Name: _____

This interview is intended to be used as a data collection method for Mr. Lannen and for use in his completion of a Master's Degree from Montana State University. Participation in this interview is voluntary and participation or non-participation will not affect the student's grade or class standing in anyway.

- 1) What is your overall impression with Honors Chemistry?

- 2) Do you feel the course is easy or difficult for you to succeed in?
 - a) Why do you feel this way?

- 3) Do you have opportunities to let your opinions/suggestions be known in class?
 - a) Do you feel that these would be listened to or acknowledged?

- 4) Do you feel that by using Plan, Do, Study, Act (PDSA), that the class is easier?
 - a) Why or Why not?

- 5) Has using formatives in the PDSA cycle helped you in the class?

a) Why or Why not?

6) Do you feel that you are remembering the material better since the start of PDSA?

7) Are there any suggestions that you have to make the material more manageable?

APPENDIX D

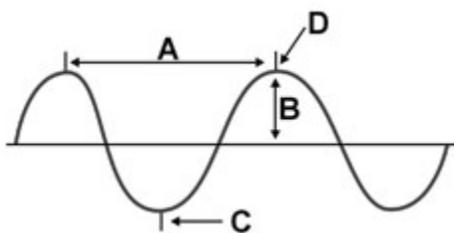
UNIT 5 FORMATIVE EXAM EXAMPLE

Honors Chemistry Chapter 5 Formative

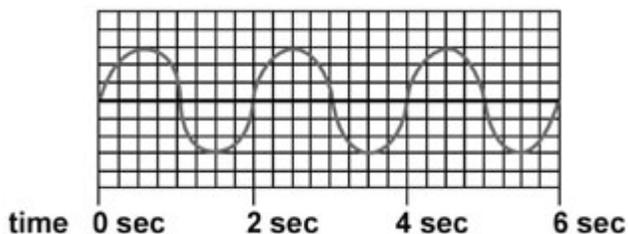
Name: _____

Multiple Choice

Identify the choice that best completes the statement or answers the question.



- ____ 1. Which label identifies the amplitude of the wave shown?
 a. A
 b. B
 c. C
 d. D
- ____ 2. Which label identifies the wavelength of the wave shown?
 a. A
 b. B
 c. C
 d. D
- ____ 3. Which label identifies the trough of the wave shown?
 a. A
 b. B
 c. C
 d. D
- ____ 4. Which is the frequency of the wave shown?



- a. 2 Hz
 b. 0.5 Hz
 c. 2 sec
 d. 3λ
- ____ 5. Which element has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$?
 a. Titanium (Ti)
 b. Chromium (Cr)
 c. Sulfur (S)
 d. Selenium (Se)

APPENDIX E

IRB CONFIRMATION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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Administrator:
 Cheryl Johnson
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MEMORANDUM

TO: Scott Lannen and Walt Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn MD*
DATE: October 18, 2012
RE: "How Will Student Scores be affected by Incorporating Plan, Do, Study, Act (PDSA) Strategies in the Chemistry Classroom?" [SL101812-EX]

The above research, described in your submission of October 18, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX F

EXEMPTION REGARDING INFORMED CONSENT

Administrator Exemption Regarding Informed Consent

I, Bryce Anderson, Principal of Sandra Day O'Connor High School, verify that the classroom research conducted by Scott Lannen is in accordance with established or commonly accepted educational settings involving normal educational practices and that I approve the project. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Scott Lannen regarding informed consent.

Bryce Anderson, Principal
(Signed Name, Title of Position)

Bryce Anderson
(Printed Name)

10/16/2012
(Date)