WHAT EFFECT DOES ADVANCED LAB PREPERATION HAVE ON STUDENT ACHIEVEMENT IN A HIGH SCHOOL ACCELERATED CHEMISTRY CLASS?

by

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ABSTRACT

The purpose of this action research-based classroom project was to study the effects of planning and preparing for lab compared to not preparing for lab and how that affected student achievement. Students took part in four labs where they prepared ahead of time, and four labs where they were given the lab procedures the day of the investigation and asked to complete their work. Student achievement and success were measured using questionnaires, surveys, and teacher observations during labs. There were eighteen Bellevue High School students in the accelerated chemistry class who participated in this study. During both treatments, the students were engaged in labs and indicated that they felt comfortable with the material that they were learning in class and how it compared to the lab experiment. When students prepared on their own for lab they consulted books, YouTube, the internet, and peers more than they did when they didn't have to prepare on their own. The results indicated that students were more successful, comfortable, and prepared for lab when they prepared on their own vs. when they were given the lab procedures the day of class. Although the students were more successful and comfortable when they prepared, this study also indicated that students enjoyed the hands-on experience during all labs.

INTRODUCTION AND BACKGROUND

Overall, I have five years of teaching experience and for the past six months I have been teaching at a rural school in Bellevue, Ohio. I am certified in grades 7-12 Integrated Science Education and also hold a Bachelors Degree in geology. I am currently teaching accelerated chemistry and physics to juniors and seniors. Bellevue High School is located in Huron County and is about 20 minutes south of Sandusky, Ohio. The current enrollment at the high school is 651 students. The majority of the families in the community are lower- to middle-class working Americans. Bellevue High School was rated Excellent by the state of Ohio last year and as a school district they were rated Effective (ODE, 2012).

Currently at the high school students have the option of taking traditional high school coursework, advanced placement, dual credit, honors, vocational coursework, and both part- and full-time post-secondary coursework. Most of the students at the high school are taking one or more of these options. As of this year at Bellevue High School, there are 116 students enrolled in chemistry and of those students 18 of them are enrolled in the accelerated course. Of the 18 students who are in the accelerated course, there are13 girls, 5 boys, 17 juniors and 1senior. This is the first year that Bellevue has offered an accelerated chemistry course. The accelerated course moves at a faster pace, and it also has a different curriculum and grading scale than the general chemistry course. Most of the students who are enrolled in the accelerated course are taking one or more college courses as well as a non-traditional full-time high school coursework.

Until their junior year most of the lab work that high school students participate in requires little to no preparation outside of class. Most of the time when students

participate in lab in the lower science classes the lab-work is teacher centered. Upon arriving to class, students obtain their lab handouts, and the teacher reviews the lab material and lab procedure, immediately before the students complete the lab. Students are not required to prepare for the lab content before class begins. By the time students enter their junior year of high school, they have not prepared for any lab outside of class. The upper level science classes in high schools are designed to move at a faster pace with a more hands-on approach to learning. Chemistry and physics are more independent sciences thus requiring more preparation from the students. There are students in high school who are opting to take their high school science courses through colleges, with little to no inquiry-based problem solving lab experiences.

When juniors and seniors in high school opt to take their upper level science courses in college, they generally have not had the proper experiences in the lab setting. Most students who choose not to take high school chemistry and/or physics are not prepared for college science classes because in most cases they have not had a lab experience with the same requirements for their college classes. The typical college chemistry course requires pre-lab work where the student has to research the lab work outside of class on his/her own. These students are required to do the work before they enter the lab or class without teacher supervision. Most high school students are not exposed to this type of work until their senior and possibly their junior year. Students are then typically expected to prepare a lab write-up to report their findings. In some cases the students must use their inquiry-based problem solving skills prepare a procedure to determine how to solve the problem in the experiment. One of the main goals of this research was to introduce students to a different way of thinking about chemistry labs

prior to the students taking coursework at the college level. This project also helped students who were taking on-line coursework, vocational coursework, or other general lab science coursework as a high school student. This allowed students to take the knowledge they gained in the high school chemistry lab and apply it to their college coursework. Students were exposed to the type of work that will prepare them for their college coursework in the future. In the future I hope to follow up with students and obtain feedback on how prepared the students felt as they entered their vocational studies, two-year colleges, four-year colleges, and the working force after participating in this study.

The main focus question of this research project was: what effect does advanced lab preparations have on student achievement in a high school accelerated chemistry class? I also asked two sub questions: Will allowing students to prepare for lab ahead of time mean they are better prepared to do their lab in the allotted amount of time? Will preparing for class alleviate the stress that students often feel when they are in lab and are in a time crunch to spend more time reviewing directions instead of just learning lab concepts?

CONCEPTUAL FRAMEWORK

Laboratory practices in high school science class and beyond are very important in the sciences. In the state of Ohio, it is mandated that all students have three science classes in order to graduate. The third science class that students are required to take is an upper-level, lab-based class. These classes consist of lab science classes in chemistry, physics, upper-level biology, and astronomy. The definition of a lab science class in the state of Ohio is one in which there will be student centered learning, with a problem-

solving component throughout the course. The state requires students who want to graduate with honors take two of these classes (ODE, 2012).

One of the emerging ways of thinking in the lab allows for students to have better lab preparation time and also allows for the students to have a positive experience in the lab setting (Steen, 2011). There has been a change in the traditional approach to lab work because there are a lot of students who go through the motions of labs and have a hard time making connections between their lab work and their lecture work (Layman & Kirk, 1996). In the education field traditional lab work is often referred to as a cookie-cutter lab. These are labs where students follow a scripted, cookbook lab exercise. When students are performing this type of lab, there is little to no critical thinking involved, and the students simply regenerate the information instead of learning the context of the lab (Longo, 2011). With traditional lab work, students often enjoy performing the lab, but they do not absorb the concepts that they are learning and have a hard time applying those concepts in the classroom setting (Putti, 2011). One of the reasons that students are apprehensive about trying new approaches in the classroom is because they are afraid they are going to fail, and students may also have a hard time learning new concepts (Falconer & MacNeil, 2010). Another reason that lab work has been revamped is that the "old" style labs or cookie-cutter labs do not allow for students to have a full understanding of the concept. When students follow cookie-cutter lab, they go through the motion of application by following step by step procedures to find an outcome and cannot apply the concepts learned in class to the lab (Wellnitz, 2011). The traditional way of thinking is less successful and not a practical application of science for the real world (Ealy & Pickering, 1992).

The purpose of obtaining an honors diploma or taking advanced placement classes in Ohio is to help students prepare for college or to be college ready (ODE, 2012). One of the biggest problems with students transitioning from high school science courses to college science courses is that conceptually students are prepared for classroom content, but their laboratory skills are not up to par (Putti, 2011). In the area of lab preparation, most students entering their first year of college lacked critical thinking skills and did not have nearly enough pre-planning experience when moving from high school science classes to college science classes (Gentry, 2002; Putti, 2011). These students also are not typically prepared for the college style lab setting (Gentry, 2002). In high school science labs, students are often given a list of lab procedures to follow with the intent that the students will meet a desired outcome. However, scientists working in the profession do not usually have a set of standards or procedures to follow. Although the scientists are generally looking for a specific outcome, the scientists do not always have a specific procedure to follow. Most of the time scientists are creating the experiment themselves (Putti, 2011). Most students entering general chemistry labs in the first year of college lack the prior knowledge of concepts because students are used to traditional labs (Wellnitz, 2011).

In pre-college work, students enjoy participating in labs, but they lack retention of material learned and often have a hard time applying what they have learned (Wellnitz, 2011). This is an area of science that needs improvement because most students enter labs having little or no background knowledge of lab procedures and expectations. The more prepared students are entering lab, the better understanding they will have of the concepts that are taking place in lab (Gentry, 2002).

One of the ways that students can prepare themselves for a laboratory experiment is to see the procedure prior to entering the lab. If students are prepared for the lab before they come to the lab room, they will ask fewer questions and have a better understanding of the concepts that are being presented in lab (Ealy & Pickering, 1992). When students were not provided with a specific lab procedure, but were provided with pre-questions and preparations, 41% of students in the college setting said they felt better and more prepared for their lab work (Gentry, 2002). At the college level, professors are making the earlier preparation for lab as a grade, and in some cases the grade for the pre-lab questions was weighed more than the actual lab itself. Students who participated in class and prepared for lab ahead of time were better prepared to engage in lab and class concepts and generally are more engaged in both settings (Gentry, 2002; Lloyd, 1992; Layman & Kirk 1996). There are many colleges that require students to do pre-lab guides, questions, or lab activities before entering the lab (Gentry, 2002; Layman, & Kirk, 1996).

There was a direct correlation with high school students who were allowed to prepare for the lab the night before with pre-lab questions and also with lab preparations ahead of time and their success (Ealy & Pickering, 1992). The students in this study who prepared for the lab before coming to the lab classroom scored higher on the test in the application portion of the test than the other groups (Ealy & Pickering, 1992). These students also explained that they understood the concepts better with the extra preparation. In this study, the students had a more clear understanding of the lab and less misconceptions but did not feel it helped them conceptually (Layman & Kirk, 1996). On the college level the more prepared students were before lab, the better understanding and

engagement they had in the lab setting (Gentry, 2002). If students are better prepared for lab, then the lab will run smoother, students will have a better understanding of concepts, and students will be able to have a better success rate in the lab (Gentry, 2002; Wellnitz, 2011).

Based on all of the research that was collected and gathered, there was a common theme in all of the articles. The first theme was that although students perform labs in a high school environment, the students are not as prepared for labs in college and beyond. Students need to be better prepared for how labs are performed in the college setting. This research also showed that traditional labs in the high school setting were not the best choice and that students needed to be better prepared prior to the lab. These articles also showed that students who spent more time preparing for lab typically had a better understanding of the concepts that were being demonstrated in lab. The students who spent time on pre-lab activities also had a better understanding of lab applications.

METHODOLOGY

This action-research-based classroom project lasted approximately 20 weeks. The study was conducted over the following chapters: atoms and electrons, periodic trends, ionic and metallic bonding, covalent bonding, naming formulas, chemical quantities, and chemical reactions. The accelerated chemistry students participating in this study learned content related to periodic trends, structure of an atom, electron configuration, and general chemical equation reaction concepts. This was the students' first chemistry course and also their first true lab science class as stated by the State of Ohio Board of Education. Finally, the research methodology for this project received an exemption by

the Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The students participating in this study started the lab sequence with a treatment lab. Once that lab was completed the next lab that the students would participate in was a non-treatment lab. When the students were participating in the non-treatment lab, they were expected to come to classes prepared for the lab work but were not given the procedure of the lab until they entered class that day. The students already knew what the lab pertained to and the concepts that they were studying, but they did not have the lab in hand until the day they were to participate in the lab. When the students were part of the treatment lab, they were given the lab concept two or three nights before the lab took place, and they were to research the lab, get a lab procedure approved, and come to class with their notebooks ready to participate in the lab. The students were then asked to write questions they would like to explore and answer in the lab that pertained to class. During one treatment and one non-treatment lab, the students were asked to write a formal lab report. The students wrote two formal lab reports for this study and answered lab questions for all of the labs. Although not all of the lab reports were formal lab reports, the students were still responsible for answering pre- and post-lab questions for all of the labs. The students participated in four treatment labs and four non-treatment labs. Altogether the students participated in eight labs that were part of different units of chemistry.

Before students participated in the treatment, they were given The Bellevue Prior Experience Lab Questionnaire to complete (Appendix A). The questionnaire consisted of open ended questions and assessed students' lab experiences prior to coming into

chemistry. The Bellevue Prior Experience Lab Questionnaire questions provided a baseline of student opinion about previous lab experiences, as well as how often students have prepared for lab outside of class. The questionnaire also offered a baseline for how successful students felt in lab and how that related to student achievement in previous classes. The students have had prior lab experience coming into chemistry, but the labs are not as in-depth as chemistry labs. However, according to the State of Ohio's definition of a laboratory experience, students have yet to complete a lab science course until their junior year or third science class. Once the students completed The Bellevue Proper Experience Lab Questionnaire and the results were analyzed, the students began their treatment during labs. The students' data was analyzed by determining average responses and comparing those responses pre to post. The Likert scale that was used during this project was based from one to five, with one being *strongly disagreed* and five being *strongly agreed*.

When the students entered each lab, they were asked to participate in the Bellevue Advance Chemistry Pre-Lab Preparation Survey prior to completing the lab (Appendix B). The students were then asked to complete the Bellevue Advanced Chemistry Post-Lab Preparation Survey after their lab was completed (Appendix C). The students were asked a series of questions about how prepared for lab they were during this time. Students' answered based on a scale of one to five, with one being the *lowest* and five being the *highest*. The students also had one open ended question on the pre-survey and two open ended questions on the post survey. Students completed these questions for the duration of the study every time they were in lab. The survey was administered to obtain students' feelings toward lab preparation, as well as getting feedback from students in

reference to the treatment. Once the treatment period was over, the students were asked to participate in The Bellevue Advanced Chemistry Post Lab Questionnaire (Appendix D). This questionnaire was used to see how their feelings toward labs changed over the duration of the study and also to obtain feedback. This data was collected using a Likert scale and the student data was analyzed and converted into percents. Once the data was converted into percents the data was studied and trends were applied.

While the students were completing surveys for each of the labs, observations were made by me and kept in a journal (Appendix E). In the teacher journal I detailed what the students were doing during the lab period. As a teacher I also compared how the students were doing when it came to the lab and classroom content by asking informal interview questions and charting their responses (Table 1)

Table 1
Data Triangulation Matrix

Focus Question *Primary Question*	Data Source 1	Data Source 2	Data Source 3
What effect does preparing for lab in advance have on student achievement?	1 .Prior Experience Lab Interview Questionnaire 2. Student Post Lab Experience Interview	1. Bellevue Advanced Chemistry Pre-Lab Preparation 2. Bellevue Advance Chemistry Post Lab Preparation Survey	1.Lab Notebook 2.Scores and 3.Teacher Notes
Secondary Questions			
1. What effect does lab preparation ahead of time have on student learning compared to no preparation before lab?	1. Prior Experience Lab Interview Questionnaire 2. Bellevue Advanced Chemistry Pre-Lab Preparation 3. Bellevue Advance Chemistry Post Lab Preparation Survey 4. Student Post Lab Experience Interview	1. Bellevue Advanced Chemistry Pre-Lab Preparation 2. Bellevue Advance Chemistry Post Lab Preparation Survey	1.Teacher 2.Observations and Student Lab 3.Notebooks
2. Will allowing students to prepare for lab ahead of time mean they are better prepared to complete their lab in the time allotted?	1. Prior Experience Lab Interview Questionnaire 2. Bellevue Advanced Chemistry Pre-Lab Preparation 3. Bellevue Advance Chemistry Post Lab Preparation Survey 4. Student Post Lab Experience Interview	1. Bellevue Advanced Chemistry Pre-Lab Preparation 2. Bellevue Advance Chemistry Post Lab Preparation Survey	1.Teacher Observations and Student Lab 2.Notebooks.
3. Will preparing for class alleviate the stress that students often feel when they are in lab and are in a time crunch or have to spend more time reviewing directions instead of just learning the lab concepts?	1. Prior Experience Lab Interview Questionnaire 2. Bellevue Advanced Chemistry Pre-Lab Preparation 3. Bellevue Advance Chemistry Post Lab Preparation Survey 4. Student Post Lab Experience Interview	1. Bellevue Advanced Chemistry Pre-Lab Preparation 2. Bellevue Advance Chemistry Post Lab Preparation Survey	1.Teacher Observations and 2.Student Lab Notebooks.

DATA ANALYSIS

Results from the Bellevue High School Pre-Lab Questionnaire indicated that 100% of students (*N*=18) had never participated in a course that was considered a lab science. Although students had never participated in a class that was considered a lab science, they had all participated in labs in their physical science class as well as their biology class. As a result, 77% of students indicated that all of the labs that they have participated in correlate to the class content. One student stated that "labs help to give me a sense of clarity of the concept that we are learning in the class." While 77% of students indicated that labs helped them, 6% of the students did not feel that labs helped them, and 18% of students felt indifferent about the lab situation. When students were asked if they had ever prepared for lab ahead of time, 100% of the students indicated they had never prepared for lab outside of class and were given lab handouts the day of the lab. Students were asked if they felt pressured and stressed to finish labs in the allotted time. Sixty-one percent of students said they did feel stressed and pressured to finish in the allotted time. One student said, "Labs are fun, but can be stressful when we do not know what is happening ahead of time." There were 28% of students who indicated that the stress and pressure depended on the lab and the material. One student said, "stress and pressure depended on how much they understood the concept and practiced beforehand." There were 11% of the students who said they didn't feel stressed or pressured. When students were asked if they had ever had to write a formal lab report, unanimously students responded that they only had to answer lab questions and never a formal lab report.

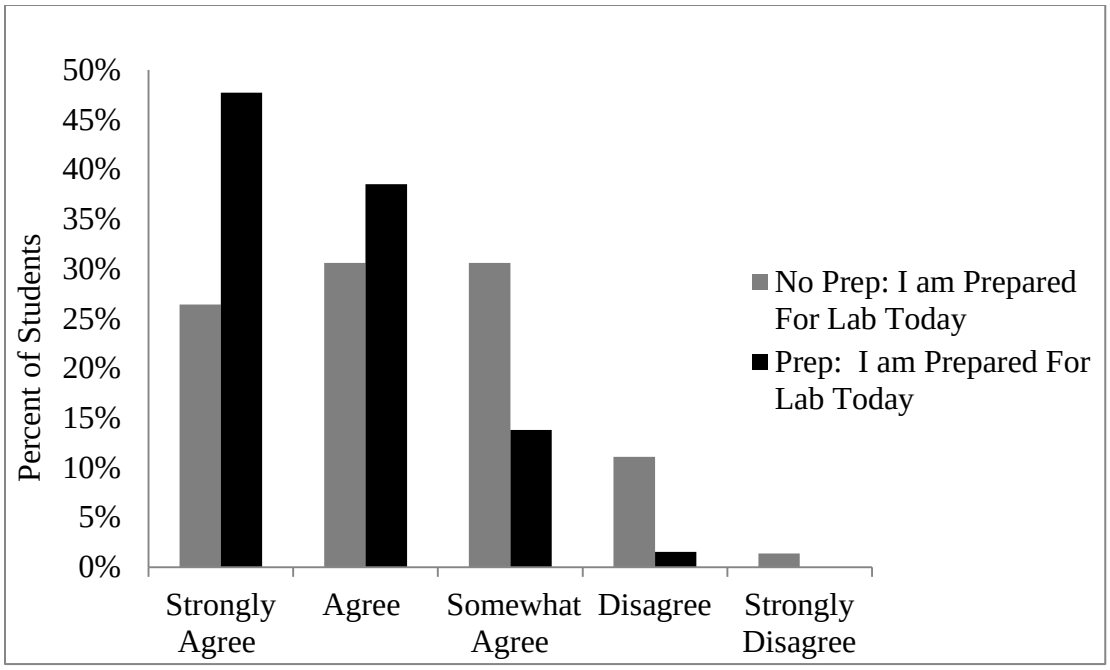

Figure 1. Lab preparation ahead of time *(N* = 16*)* vs. no lab preparation ahead of time, (*N* = 18).

Before the students participated in labs that they had prepared for and labs that they had not prepared for, they were asked to rate if they were prepared for the lab that day (Figure 1). Out of four labs where the students did not prepare ahead of time, 26 % indicated that they *strongly agree* that they were prepared ahead of time, 30 % of the students *agree*, 31% of the students *somewhat agree*, 11 % *disagree*, and 1.4% *strongly disagree*. When the students were asked the same question during the times that they did prepare ahead of time, 48% of students *strongly agree* that they were prepared, 39% *agree*, 14% *somewhat agree*, 1.5% *disagree* and no students *strongly disagree*. Students were then asked to indicate what resources they used to research or prepare for labs the day before or the day of the lab. Most of the students indicated on the days that they did not prepare for the lab they consulted their books, notes, and the lab handout given by the teacher. On the days that the students had to prepare on their own they consulted You

Tube, internet, texted friends, called friends, their books, their notes, and they prepared their lab notebooks ahead of time (Table 2).

Table 2
Resources Students Used to Prepare for Different Lab Scenarios

Preparing for Labs Ahead of Time	Lab Preparation the Day of Lab
Talked to Friends Read the Chapter Planned and Prepared Notebook Read Over Notes Texted Friends Consulted the Internet Consulted YouTube Consulted the Book	Read the Teacher Handout Talked to Friends Read the Chapter Read Over Notes Prepared Lab Notebook

Table 3
Time Students Spent in Lab: Preparation vs. No Preparation

Lab Preparation	No Lab Preparation
40 Minutes Percent Composition of Sugar in Bubble Gum	50 Minutes Metallic Bonding
40 Minutes Electron Configuration By Flame Testing	60 Minutes Percent Composition of Magnesium
50 Minutes Figuring out the Polarity of Food Dye Using Chromatography	70 Minutes Identifying Ionic and Covalent Bonds
60 Minutes Modeling Structural and Molecular Formulas	100 Minutes Deciphering Periodic Trends
Average Completion Time: 48 Minutes	Average Completion Time: 70 Minutes

Student engagement was monitored throughout all of the labs, and time was kept throughout all of the labs. Student engagement was being monitored and time was kept for all of the labs that students participated in (Table 3). On average, when students prepared for labs ahead of time they spent 48 minutes in groups of two or four to complete their lab task at hand. When students did not prepare for lab ahead of time,

they completed their lab in an average of 70 minutes in groups of two or four. In time length, the shortest lab for preparation ahead of time was 40 minutes and that was when students were figuring out the Percent Composition of Sugar in Chewing Gum. When the students prepared ahead of time, they spent the longest amount of time when they were building structural and molecular models of different formulas. The students spent 60 minutes on this lab. When the students didn't prepare for lab ahead of time, the shortest time they spent in lab was 50 minutes, and they were working on the concept of metallic bonding. Time-wise students spent more time on projects for which they did not prepare. Students spent the most time in lab when they were deciphering periodic trends, and it took most groups 90-100 minutes to complete the lab.

The students on average were asked to stay on task more during the days that they had prepared for lab ahead of time. On average, there were four times throughout the four labs that I had to ask students to get back on task and stay alert. When students did not prepare ahead of time, there was only one offender each time who was asked to stay on task. Although students were engaged during all of the lab situations, the students were asked to stay on task more when they had prepared for their lab ahead of time.

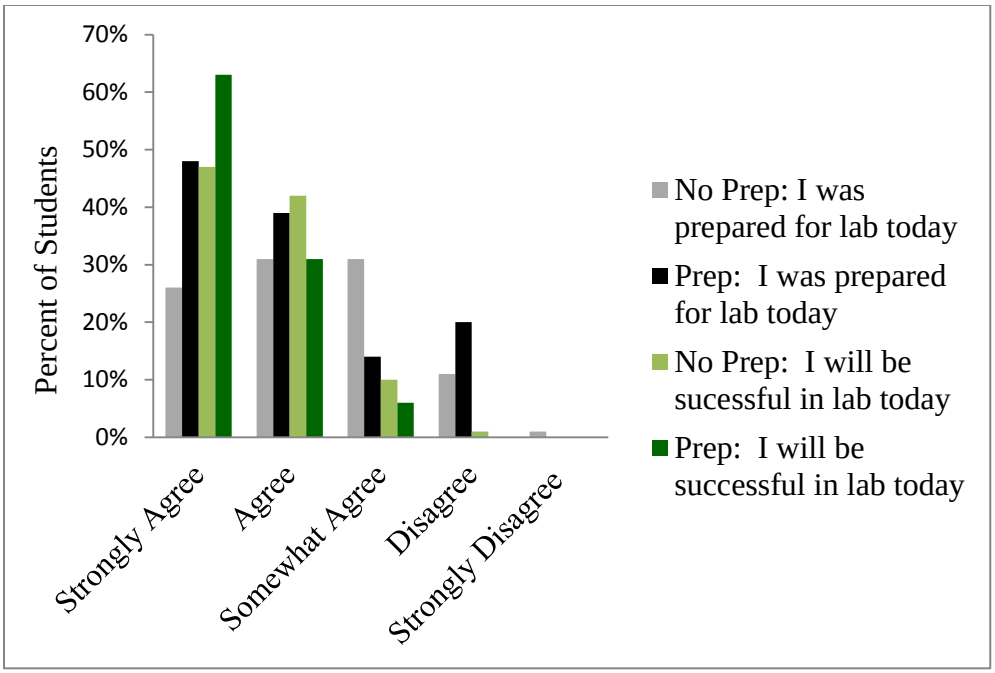

Figure 2. Student lab preparation (*N* = 16) vs. no preparation (*N* = 18): I was prepared for lab today vs. I will be successful in lab today.

When students had not prepared ahead of time and before their lab began, students were asked if they felt prepared for lab that day and if they were going to be successful in lab today (Figure 2). Students were asked if they felt prepared for lab today and if they were going to be successful in lab today, before their lab began, when they hadn't prepared ahead of time. There were 26% of students who *strongly agree* that they were prepared, and 47% of students *strongly agree* that they would be successful in lab today. There were 31% of students who *agree* that they were prepared for lab today and 42% *agree* that they were going to be successful in lab today. There were 31% of students who somewhat *agree* that they were prepared for lab today and 10% of students that *somewhat agree* that they would be successful in lab today. There were 11% of students *disagree* that they were prepared for lab today and 1.4% of students *disagree* that they would be successful in lab today. Finally, 1.4% of students *strongly disagree*

that they were prepared for lab today and 0% of students *strongly disagree* that they would be successful in lab today.

When students were asked the same two questions about being prepared for lab and being successful in lab when they prepared ahead of time, the results differed (Figure 2). There were 48% of students who *strongly agree* that they were prepared for lab, and 63% of students who *strongly agree* that they would be successful in lab today. There were 35% of students who *agree* that they were prepared for lab today, and 31% of students who *agree* that they would be successful in lab today. There were 14% of students who *somewhat agree* that they were prepared for lab, and 6% of students who *somewhat agree* that they would be successful in lab. Finally 1.5% of students *disagree* that they were prepared for lab, and 0 % of students *disagree* that they would be successful.

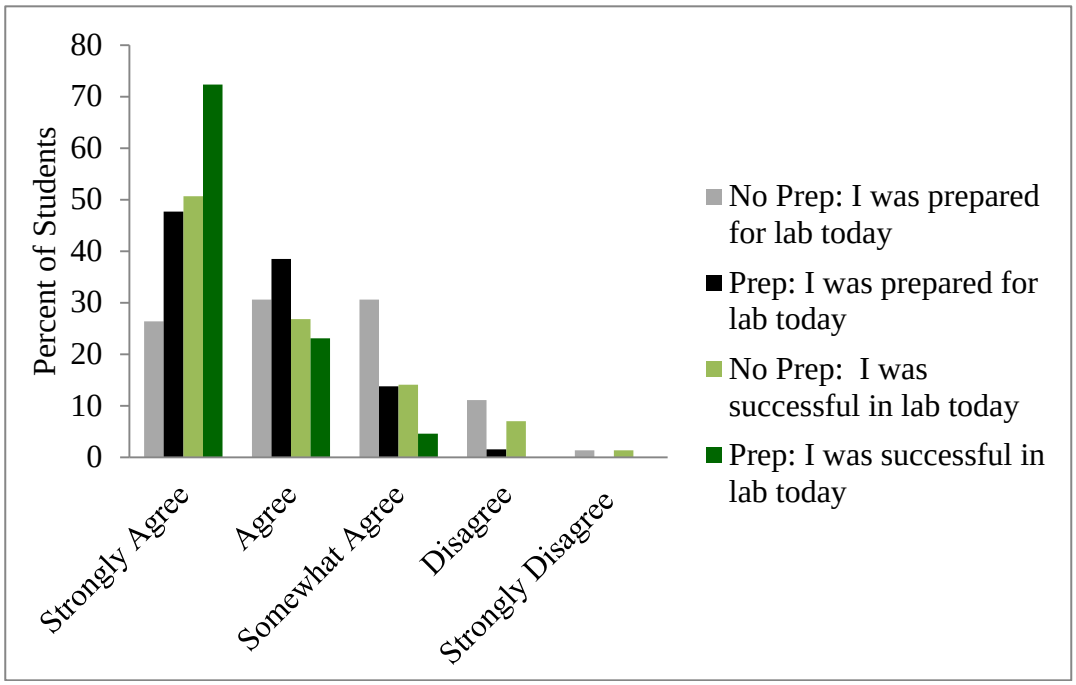

Figure 3. Student lab preparation (N = 16) vs. no preparation (*N* = 18): I was prepared for lab today vs. I was successful in lab today.

With no lab preparation ahead of time, students were asked to fill out surveys and indicate, if they were prepared for lab, and after the lab was over they were to indicate if they were successful in lab that day (Figure 3). There were 26 % of students who *strongly agree* that they were prepared for lab before the lab, and 51% of students *strongly agree* that they were successful in lab after their lab was completed. There were 31% of students who felt somewhat prepared for the lab before they started, and 27% of those students felt that they were *somewhat successful* in their lab after it was completed. There were 11% of students who *disagree* that they were prepared for lab, while 7% of students felt that they were successful in lab. Finally, 1.4% of students *disagree* that they were prepared before lab and successful after lab.

With lab preparation ahead of time, students were asked to fill out surveys and indicate if they were prepared for lab, and after the lab was over if they were successful (Figure 3). There were 48% of students that *strongly agree* that they were prepared for lab ahead of time, and 72% of students who *strongly agree* that they were successful in lab. There were 39% of students who felt that they were prepared for class, and 23.08% of students who *agree* that they were successful in lab. There were 14% of students who *somewhat agree* that they were prepared for lab, and 5% of that students *somewhat agree* that they were successful in lab. There were 1.5% of students who *disagree* that they were prepared for lab, and 0% of students *disagree* that they were successful in lab. There were no students who *strongly disagree* with being prepared or being successful in lab.

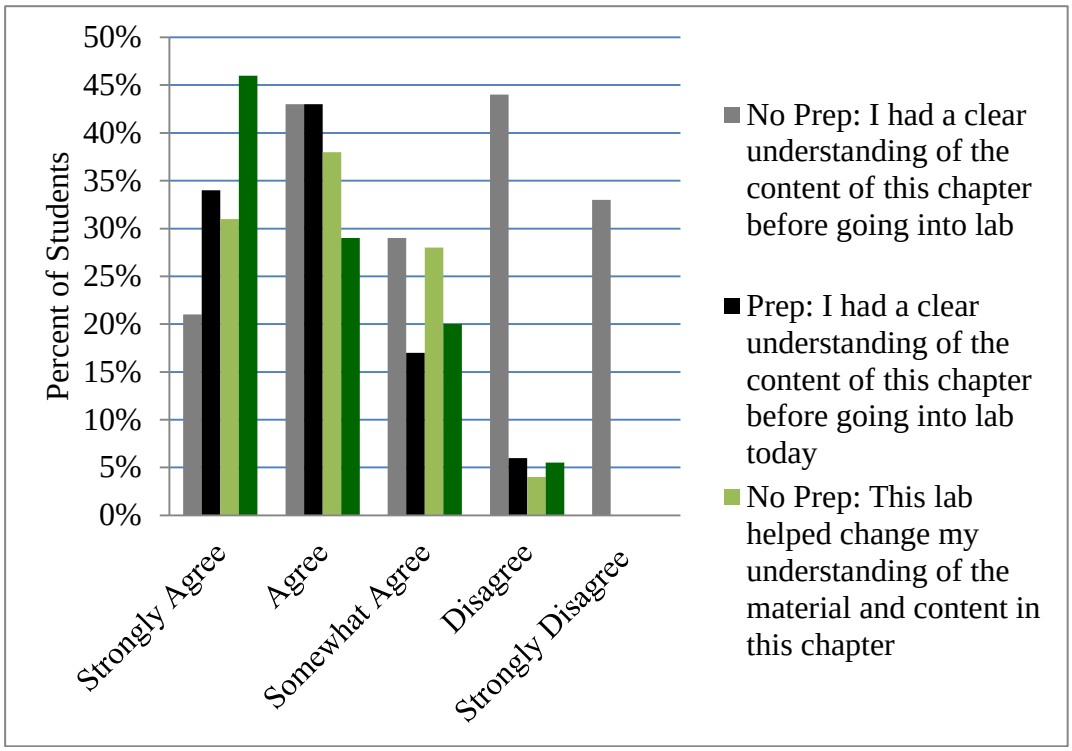

Figure 4. Student lab preparation (N = 16) vs. no preparation(N = 18): I had a clear understanding of the content of this chapter before going into lab vs. This lab helped change my understanding of the material and content in this chapter.

Students were asked prior to the lab starting if they had a clear understanding of the content of the chapter going into lab (Figure 4). Students were then asked at the end of the lab if the lab helped change their understanding of the material in the chapter. Students were asked this on the days where they didn't prepare as well as the days that they did prepare. On the days where the students did not prepare, 21% of students *strongly agree* that they had a clear understanding of the concept, and 30% of students *strongly agree* after the lab was over that the lab helped to change their understanding. There were 43% of students who *agree* that they had a clear understanding of the content before the lab, and 38% of students *agree* that the lab helped to change their understanding of the content. There were 29% of students who *somewhat agree* that they had a clear understanding of the content before lab, and 28% of students *somewhat agree*

that the lab helped to change their understanding of the material in the chapter. There were 4 % of students who *disagree* that they had a clear understanding of the content before the lab, and 4% of students who *disagree* that the content in the lab changed their understanding of the material in the chapter. Finally, there were 3% of students who *strongly disagree* that they understood the content of the chapter and 0% of students who *strongly disagree* that their understanding changed after the lab.

On the days where the students had prepared for lab on their own ahead of time (Figure 4), 34% of students *strongly agree* that they were comfortable with the content of the chapter, and 46% of students indicated that after the lab was over they had a better understanding of the content in the chapter. There were 43% of students who *agree* that they had an understanding of the material in the chapter before lab, and 29% of students *agree* that their perception changed after the lab was over. There were 17% of students who *somewhat agree* that they understood the material in the chapter before the lab started, and 20% of students *somewhat agree* that the lab changed their understanding of the content in the chapter. There were 6% of students who *disagree* that they were comfortable with the material of the chapter before entering lab, and there were 5% of students who *disagree* that the lab helped them understand the content of the chapter after the lab was over. There were 0% of students who *strongly disagree* that they were comfortable with the chapter material before the lab, and 0% of students *strongly disagree* that their understanding changed after the lab.

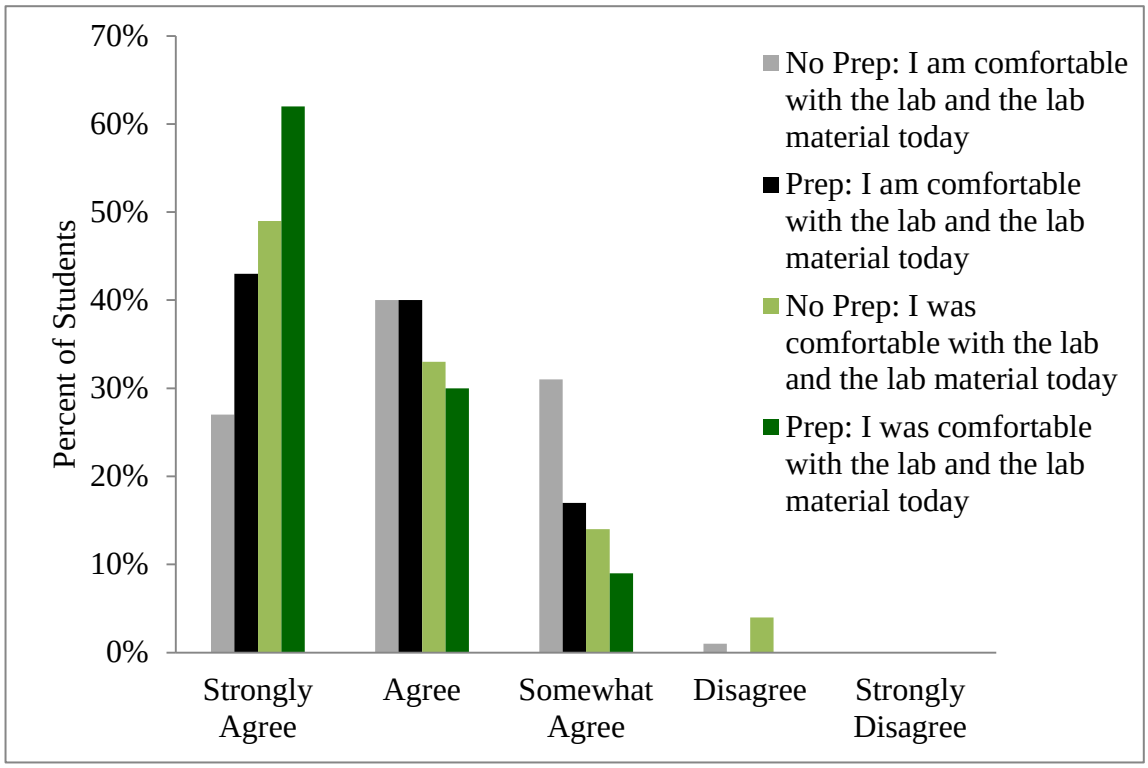

Figure 5. Student lab preparation (*N* = 16) vs. no preparation (*N* = 18): I am comfortable with the lab and the lab material today vs. I was comfortable with the lab and lab material today.

Students were asked on both days of preparation and days of non-preparation if they were comfortable with the lab material before the lab began and again after the lab was over (Figure 5). When students did not prepare for lab ahead of time, 27% of students *strongly agree* that they were comfortable with the material, and after the lab was over 49% of students *strongly agree* that they were comfortable with the lab material. There were 40% of students who *agreed* that they were comfortable with the lab material before lab, and there were 33% of students who *agree* that they were comfortable with the lab material after the lab were over. There were 31% of students who *somewhat agree* that they were comfortable with the lab material before lab and there were 14% of students who *somewhat agree* that they were comfortable with the material after lab was over. There were 1% of students who *disagree* that they were

comfortable with the material before lab started and there were 4% of students who disagreed that they were comfortable with the material after the lab were over. There were not any students who *strongly disagree* with being comfortable with material before or after lab.

When the students prepared for lab ahead of time (Figure 5), there were 43% of students who *strongly agree* that they were comfortable with the material before lab, and there were 62% of students who were comfortable with the material after the lab were over. There were 40% of students who *agree* that they were comfortable with the material before lab began, and there were 29% of students who agreed that they were comfortable with the lab material after the lab was completed. There were16% of students who somewhat *agree* that they were comfortable with the lab material before lab started, and 9% of students who *somewhat agree* that they were comfortable with the material after the lab was over. There were 0% of students who disagreed and *strongly disagree* that they were comfortable with the lab material before lab started and also after the lab was over.

When students were asked on the Bellevue Post Project Questionnaire if they felt more successful on the days that they prepared vs. the days they did not prepare, 89% of students *agree* that they were more successful when they prepared for lab ahead of time. One student said, “Yes, when I prepared ahead of time I was more successful because I was organized, and already knew what I was doing.” Another student stated, “More in the labs that I prepared for because I understood more of what was going on and I went into lab understanding and knowing what my end goal was.” However, 11% of students said that it didn’t matter in the end. One student stated “I don’t feel that either way

prepared me more or less, a lab is a lab." When students were asked on the end survey if they felt they understood the concept more or less when you prepared ahead of time vs. not preparing ahead of time, 83% of the students said they understood the concept better preparing ahead of time, while 17% of students felt it didn't make a difference. One student stated, "I felt that I understood the concept more when I prepared for the lab vs. not preparing because I had to do the research and I had more background information." Another student stated, "I did not understand the concepts any better, but I understood the procedure better when I had to do it on my own." It was unanimous among the students that they did not enjoy writing formal lab reports, and preparing ahead of time vs. no preparation did not make lab reports any easier for them to write. When students were asked what their closing remarks were, many students did not answer, but the one's that did said the following: "Based on the first labs compared to the labs that we are doing now, I feel that preparing ahead of time helped me to improve my lab skills." Another student stated, "Preparing for labs ahead of time helped me a lot and helped me to better understand the materials and concepts that we were working with."

INTERPRETATION AND CONCLUSION

Throughout this project, it was evident that students' skills in the lab, and their ability to think critically and outside of the box grew. One student said, "I feel that my lab skills have improved." Talking to other students who are taking physics and chemistry concurrently, one student told a group of students, "I wish that we prepared for labs ahead of time in physics like we do in chemistry because it makes the understanding piece a lot better, and you already know what you are doing in the lab." Based on the data that was collected, the students always appeared more confident when they were

prepared for lab ahead of time. The data that was collected during this action research project confirmed most of the research completed in the conceptual framework portion of the paper.

Although working with the accelerated class had its challenges, overall it was a pleasant experience. In one study (Falconer & MacNeil, 2010), researchers found that one of the reasons that students are apprehensive about doing new things is because they are afraid to fail and have a hard time learning new concepts. This type of data was also evident both when the students were introduced to the concepts as well as introduced to writing formal lab reports. In the end, the students still had a hard time working through the lab reports, but most of them liked preparing ahead of time vs. not preparing ahead of time because they felt prepared.

One of the purposes of an educator is to make sure that students are retaining the information that they are learning in the courses that they are taking. Students showed in a previous study that they enjoyed participating in labs but lacked retention. These students also had a hard time applying what they learned in lab to class concepts (Wellnitz, 2011). In the labs that the students completed successfully, it is evident that learning occurred more than when the students were not successful. When students were asked informal questions about what they learned in the two different types of labs, they were better able to discuss the results of the experiments that they successfully completed. Students had a harder time explaining the concepts when they were not successful in lab.

As with all research in the science field after the study is completed, there are always new questions that are raised and the quality of the research always comes into

question. Although the results of this project were both satisfying and important for how labs will be conducted in the future, there are a few aspects of the study that would be changed in the future. The first aspect of change would be the sample size. As far as the quality of research in the future, using a larger number of students would be better as it would give more reliable data. For this action- research-based project the number of students changed mid-way through the project due to absences and new students. Although during action-research-based projects the teacher initially chooses the class or students they are to use, in this case the addition of students and small class size caused minor problems when students were absent from class.

Secondly, one of the other aspects of this action-research-based project that can be examined and improved would be the varying degree and difficulty of labs on the days that the students had to research vs. the days that the students didn't have to research. In the future of this project, one of the questions raised is, will students be more successful in the chemistry classroom if they are doing projects that are strictly inquiry based? Another question for the future of this study would be how do all types of students fair with a hands on approach to chemistry and how successful will the students be in the classroom? In the future I would like to carry out this research project again using a larger sample size and perhaps include my physics classes too.

Overall, this project demonstrated and answered the initial research question of will preparing ahead of time effect student achievement. The students at Bellevue High School were more prepared and more successful in labs where they prepared ahead of time. The data of this study runs concurrent with the data that was collected for the conceptual framework. Students who prepared for labs ahead of time also had a better

understanding of the concepts in which they were going to study. This study not only allowed for students to be successful in the lab by preparing ahead of time, but it also allowed for students to connect the data that they were collecting to the class concepts that they were learning.

VALUE

This project was challenging, refreshing, and most of all insightful. I have always been a child of science and loved everything that was science involved. When I went to college, I did not feel prepared for my first chemistry lab. Now as an educator, I want students to be prepared for the future and enjoy their science classes. The students that I had the pleasure of working with throughout this experiment were wonderful. These students were wonderful because I changed the way that they were used to doing work. This group of students was always more than willing to dive into the labs, problems, and this research project head first with no questions asked.

Although the study did not go exactly how I wanted it to, I believe it still went well. There were a few challenges that I had to overcome for the study to take place. In the beginning I wanted to use the grade aspect to show the success of the students, but with the class I had it was impossible. All of the students in that class were high achieving students, so grades could not be used. As a result I had to use alternative methods to measure their success, such as, lab reports, observations, and a student questionnaire. This helped to change my perspective as an educator because as an educator I can get a lot of information from students without using their grades.

Observing how students participated in lab and also observing how well they worked when they were prepared for lab was insightful for me. This study helped me see

that as an educator I need to do more in the classroom to prepare students for lab ahead of time so that they have a better understanding of the content and task at hand. I have had the pleasure of working with two of the students in both this class and in my physics class. One day I overheard a conversation between one of the students who participated in the research and one of the students in my physics class. This conversation was almost as insightful as the data that was collected. The gist of the conversation was that the student who didn't participate in the study said that would be an awful thing to do because it would essentially be more work. The rebuttal of the student who participated in the study explained that she thought the same thing, but in the end she liked it more because she could visualize what they were supposed to be doing in lab instead of going through the motions of the lab.

This project has helped the way that I plan to do labs in the future because I do not just want students to go through the motions of lab. I think that allowing students to prepare ahead of time for their labs will allow them to have a better and more concrete understanding of the concepts. Chemistry and physics are both physical science classes, and there are so many concepts that students can learn by doing hands-on experiments. This study has definitely shaped how I plan to prepare labs in the future so that all students in my classes are successful and comfortable with the lab material.

Allowing students to plan and prepare ahead of time will allow students to use of critical thinking. Critical thinking and higher level thinking will allow for students to use these research methods and skills in practical ways outside of high school, whether they go to college or choose another career path. Ultimately, having students prepare for labs

on their own will help them to understand the concepts more because they will have more practice and structured problem solving skills that can be used in everyday life.

This action-research-based project helped to shape the way that I plan to teach these two topics in the future. Overall, I am glad that I chose this topic, and look forward to sharing it with my colleagues. I also hope to hear from the students who participated in the study and are attending college. I would like to know if the students felt that they were prepared for their college science courses and if participating in this study helped them. Hearing from students will not only validate the study, but it will help me grow even further as a teacher. If there is more evidence beyond the data that I have already collected, this will strongly impact how I teach labs to students in the future. Doing this action-research-based project has helped open my eyes to how students think and it has also helped me to challenge the accelerated chemistry students. As a teacher it has helped me grow to become a stronger science educator.

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APPENDICES

APPENDIX A

BELLEVUE HIGH SCHOOL PRIOR EXPERIENCE LAB INTERVIEW QUESTIONNAIRE

Bellevue High School Prior Experience Lab Interview Questionnaire:

1. Over the course of all of your science classes that you have taken have you ever prepared for lab outside of class? If so How?
2. When you come to lab do you feel prepared ahead of time?
3. In the course of your science classes what approach do you personally take for preparing for lab?
4. Over the years in science classes what has been your approach to finishing the lab during the allotted time?
5. Does coming to lab not prepared make you feel stressed out during the lab period?
6. When coming to lab do you feel pressured for time to finish the lab?
7. Does coming to lab and being pressed for time make you feel stressed out?
8. Do you typically follow the lab step by step or skip around?
9. Do you usually depend on your lab partner to successfully complete your lab?
10. Does the lab content usually compare to the classroom content why or why not?
11. How does the lab usually correlate to your understanding of the concepts that were being used in class?
12. Do you feel like labs help you to see the concepts that you are being taught in class why or why not?
13. When doing labs and preparing for them the day of, how comfortable to you feel on the material? 1-10 (10 being the best)
14. In what other classes have you had to write formal lab reports or have the lab reports been questions associated with the lab rather than writing a report?
15. Do you have any closing remarks?

Disclaimer: Participating in the data collection is volunteering, and it will not affect your grade or standing in the class.

APPENDIX B

BELLEVUE ADVANCED CHEMISTRY PRE-LAB PREPARATION SURVEY

Bellevue Advanced Chemistry Pre-Lab Preparation Survey

Question	Scale
I was prepared for lab today.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
I had a clear understanding of the content of this chapter going into lab today.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
I felt that this lab compared to classroom content.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
I will be successful in lab today.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
My lab partner will contribute to my success in class today.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
I am comfortable with the lab and the lab material today.	Strongly Agree Agree Somewhat Disagree Strongly Disagree 5 4 3 2 1
In what ways did you prepare for lab today?	**Circle all that apply.** I read the chapter I texted my friend. I asked my parents for help. I called a friend. I watched a you tube video I researched ideas on the internet. I planned and prepared in my lab notebook. I did nothing. Other:

Disclaimer: Participating in the data collection is volunteering, and it will not affect your grade or standing in the class.

APPENDIX C

BELLEVUE ADVANCE CHEMISTRY POST LAB PREPARATION SURVEY

Bellevue Advance Chemistry Post Lab Preparation Survey

Question	Scale
I was prepared for lab today.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
This lab helped change my understanding of the material and content in this chapter.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
After I completed the lab, I understand more how the content of the lab relates to the chapter.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
I was successful in lab.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
My partner helped my lab success.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
I am comfortable with the lab and the lab material today.	Strongly Agree 5 Agree 4 Somewhat 3 Disagree 2 Strongly Disagree 1
What specific preparation materials helped you in lab today?	
How could you have better prepared for lab today?	

Disclaimer: Participating in the data collection is volunteering, and it will not affect your grade or standing in the class.

APPENDIX D

BELLEVUE ADVANCE CHEMISTRY POST LAB PREPARATION QUESTIONAIRRE

Bellevue Advance Chemistry Post Lab Preparation Questionnaire

1. Compared to other classes what was chemistry lab like for you?
2. On a scale of one to ten rate how much you utilized your lab partners for prepared labs and for the labs that were given to you on the day of. (one is you didn't depend on them and ten is you did depend on them).
3. How did your stress level rate for labs? Were you more or less stressed out during the labs that you prepared or the labs that were given to you on the day of?
4. Did you feel that preparing for lab ahead of time alleviated stress vs. not preparing for lab head of time?
5. Did you feel like you were more successful in labs that you prepared for or the labs that were given to you on the day of the experiment? (Explain if possible)
6. Were there any differences in the way that you mentally prepared for lab when you had to do the research on your own vs. having the teacher give you the procedure? Explain.
7. Did you feel as though you understood the concept more or less when you prepared for lab on your own or were given the labs the day of? (Be sure to cite examples of applicable)
8. When you prepared for labs ahead of time did you feel that you completed the steps with more precision or did you still skip steps?
9. How did the preparing for labs ahead of time correlate with your understanding of the concepts?
10. Did your approach to completing the lab change depending on if you prepared ahead of time vs. not preparing at all?
11. Overall, how did chemistry lab compare to other lab classes that you have taken?
12. Did preparation make any difference when you were writing your lab reports? Why or why not?
13. Overall, which way of doing labs made you feel more successful and why?
14. How did you feel on a scale from one-ten (ten being the best one being the worst) stress related when you prepared ahead of time vs. not preparing ahead of time.
15. Do you have any closing remarks?

APPENDIX E

TEACHER OBSERVATION FORM

Bellevue Teacher Observation Form

Time Interval	Task Of Groups	Off Task Behaviors	Comments
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