

THE EFFECTS OF IMPLEMENTING LANGUAGE OBJECTIVES IN A
TECHNOLOGY EDUCATION CLASS

by

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ABSTRACT

In recent years, U.S. public schools have had an influx of students for whom English is a second language (ESL). These ESL students or English language learners (ELL) have a more difficult time learning academic language compared to their native English speaking peers. The Sheltered Instructional Observational Protocol (SIOP) was developed to help ESL students succeed in classes taught in a second language. Studies have shown SIOP as an effective means of instruction for ESL, and that following SIOP in the classroom is also successful in increasing student success among non-ESL students. This paper focuses on the effects of implementing one specific feature of SIOP (setting language objectives) in a technology education elective.

In this classroom research project, the instructor implemented language objectives into alternating units of study and measured the effect of the language objectives on students' perception of content, students' peer engagement, students' confidence in science, technology, engineering and mathematics (STEM), and students' interest in STEM careers. The researcher collected data from student assessment, student journals, surveys, classroom observations and student interviews.

This classroom research project found that when working independently on design activities, students performed better when language objectives were implemented. Language objectives led to more peer-to-peer interaction, and a drastic increase in peer-to-peer questions. By setting language objectives, students became more confident in their abilities to learn STEM concepts, however, interested in STEM careers remained constant

INTRODUCTION AND BACKGROUND

Project Introduction

The United States has been coined as “the melting pot” ever since Israel Zangwill’s 1908 play. In the U.S., millions of immigrants contribute to a unique society and culture, each bringing with them a piece of home that gets blended into society. Most of us welcome the food, the art and the clothing, but what about the languages they bring? How do the many varied languages impact our education system? In the Philadelphia metro area, 15% of the metro population speaks a language other than English at home. In New York, there are 192 different languages spoken by 38% of the population, and in Los Angeles 54 % of the population have a primary language other than English (“Census Bureau,” 2015). With so many individuals speaking so many languages, teachers of all ages and subjects face a growing need to not only address content in the classroom, but overcome the many diverse languages and communication barriers as well.

I have spent the past four years addressing the needs of all kinds of learners in my technology education classroom. While most of my students speak English as a first language, I also have many students who were raised speaking Spanish, Arabic, or other languages at home. These English language learners struggle with academic English language, and the English language disparity impacts the students in all classrooms. I have found even among students for whom English is a primary language, individuals often struggle with the technical language and vocabulary in an engineering course. As a

result, I designed my classroom research project to address the need to learn academic and technical vocabulary in an Introduction to Engineering course.

School and Community Demographics

Washington Township High School (WTHS) is a public secondary school located in Sewell, New Jersey which serves students in the municipality of Washington Township (Washington Township, n.d.). The district is composed of a total of seven elementary schools that serve students grades pre-K through fifth, three middle schools for grades six through eight and WTHS for students in grades nine through twelve. Washington Township is Gloucester County's largest municipality with a population of approximately 48,500 (Washington Township, NJ, n.d.).

Washington Township has a growing population of both foreign-born citizens and individuals for whom English is a second language. In 2000, 5% of the population identified as being foreign born, and 8.9% identified as speaking a language other than English at home. In comparison, the percent of residence who spoke a language other than English at home was 9.7% in 2014 (United States Census Bureau, 2014).

Enrollment data for the 2016-2017 school year at WTHS echoes the census. As of January 2017, the white/Caucasian population decreased to 81.68% and there were a total of 15 students enrolled in the English as a Second Language (ESL) program at WTHS. The ESL program consists of students who are still learning both conversational and academic English. All of these ESL students have recently moved to the United States from a non-English speaking country (A. Marguglio, personal communication, January 23, 2017).

From a socio-economic standpoint, Washington Township's population is generally considered middle class, with some neighborhoods in an upper-middle class and some neighborhoods in the lower-class tier. Out of 11 schools in the Washington Township Public School district, five schools were considered Title I schools in the 2016 year (FY 2016 Title I Schools), including five elementary schools and one middle school. Most students who live under the poverty line are concentrated in a few common neighborhoods and attend the same elementary schools and middle school. Once students reach the high school level, all students are integrated into one large high school and with only 6.12% of students considered impoverished, WTHS is not considered Title I (2017-2018 Census).

Teaching Context

This classroom research assignment was completed during the 2016-2017 academic school year, in two Introduction to Engineering Technologies courses. The course runs as a full year elective, available to all students, which meets the New Jersey state graduation requirements for a practical art elective. The Introduction to Engineering Technologies class introduces students to the engineering design loop and computer aided drafting and design (CADD), and the course is a prerequisite for the second course in the engineering sequence and the architectural program at WTHS.

The Introduction to Engineering Technologies' curriculum adheres to New Jersey's standards for 21st Century Life and Careers, and the standards in content area 9.3 Science, Technology, Engineering & Mathematics Career Cluster. By the end of the year, students taking the Introduction to Engineering Technologies course should be able to use

STEM concepts and processes to solve problems involving design, display and communicate STEM information, apply the elements of the design process, and apply the knowledge learned in STEM to solve problems.

Introduction to Sheltered Instructional Observational Protocol

In response to the growing number of English language learners (ELL) and English as a second language (ESL) students, WTHS has spent professional development time addressing the specific needs of the ELLs and ESL students. During the 2015-2016 academic year, the Washington Township School District provided training to staff members who work with ELLs in how to prepare lessons following the Sheltered Instructional Observational Protocol (SIOP). SIOP is a program consisting of 30 features broken into eight main categories that allows teachers to meet the academic needs of ELLs in the classroom (see Table 1). The eight SIOP categories cover every aspect of teaching, from preparing lessons to lesson structure (such as building background) to assessment. Many of the features of SIOP are considered general good practice for teaching any student (such as writing content objectives for students to see, using meaningful activities, and providing sufficient wait time during discussions).

To understand what SIOP looks like in a classroom, read the following description of the “What is a Dragonfly” lesson created by Rebecca Iwasaki (2012) for her first-grade classroom:

Students spent a month reading and learning about nonfiction reading, and read *Are You a Dragonfly?* by Judy Allen. By the end of this lesson, there are two content objectives set by the instructor. First, students will be able to label the parts of a

dragonfly. Second, students will be able to identify important information about a dragonfly. In addition to the content objectives, the instructor also would like students to be able to complete two language objectives. For the language objectives, students will be able to listen to their partner's ideas about dragonflies, and students will be able to write a descriptive sentence about dragonflies and decide (turn and talk). The instructor started the lesson by identifying key vocabulary for the students (hunt and insect), and then had all students take out a dry erase board and marker and move in front of a Four Corner graphic organizer.

All students were instructed to write on their dry erase board what sounds or letters were heard at the beginning of the word "dragonfly." After all students wrote answers, the instructor wrote the word "dragonfly" in the top left section of the graphic organizer. Next, students were told to turn and tell their partner what a dragonfly is. Students needed to listen to each other, and try to agree on a common definition. In the top right square, the instructor wrote "A dragon fly is an..." and asked students to write what sounds are at the beginning of the word "insect" on their own boards. The lesson continues to go through information, in small digestible bites that engage students and require students to be involved in the process. At each step, students were instructed to turn to a partner and share information. At the end of the lesson, students were asked "what have we learned about dragonflies" and told to think the answer in their heads. After sufficient wait time, students were instructed to turn and tell a partner their answers (Iwasaki, 2012).

In this example lesson, several features of SIOP are prevalent. The lesson was prepared with content objectives and language objectives that required students work on listening and writing skills, and the lesson contained meaningful activities for the students to complete. Background was built by introducing students to the lesson by connecting it to the previous reading done in class. New vocabulary was developed, and students shared what background information they knew about dragonflies. Many strategies were used and the level of student interaction was significantly higher than a teacher centered classroom. This lesson provided frequent opportunities for interaction, and students were constantly interacting with peers. Finally, the teacher presented the class with a question and then allowed sufficient wait time for all students to process the information before requiring them to answer. The lesson's content was accessible to ELLs, and the lesson was set up such that students could make improvements in academic language development and conversational language. SIOP development and more information about SIOP will be discussed in the Conceptual Framework.

Focus Question Development

I have found that many students (from all backgrounds) lack the technical and academic vocabulary that is necessary to ask effective questions of the engineering content in my Introduction to Engineering Technologies courses and also struggle with the vocabulary required to communicate ideas when working in groups with peers. When working with abstract or creative ideas, many individual students struggle to elaborate complex thoughts and convey solutions to partners. This inability to communicate design details has limited the success of students who are working in groups on projects because

of the discontinuity of production without all group members present. With this communication barrier in mind, I developed my classroom research questions.

Purpose

- The purpose of this classroom research project was to examine the effects of implementing language objectives for all students in a general education level technology education class.

Primary Research Question

- What effect does implementing “Feature 2: Setting Language Objectives” of the Lesson Preparation component of SIOP in a technology education environment have on students’ achievement?

Sub questions

- In what ways does clearly defining language objectives impact students’ mastery of content material in a technology education class?
- In what ways does clearly defining language objectives impact student engagement with peers in a technology education class?
- How does increasing technical vocabulary impact student confidence in science, technology, engineering and mathematics?
- How does increasing technical vocabulary impact student interest in pursuing further opportunities in science, technology, engineering and mathematics?

CONCEPTUAL FRAMEWORK

The need for implementing SIOP in the classroom is tremendous in public schools across the United States. According to the United States Census Bureau, the number of students ages 14-19 attending schools in the United States who are either foreign born or whose parents were foreign born has increased by 861,000 between 2010 and 2014. In 2014, there were approximately 7.2 million students who fell into the category of being either foreign born or having parents who were foreign born (United States Census Bureau, 2014). Many of these students have developed conversational English skills, however without English being spoken at home these ESL students are at a disadvantage for learning academic language and they typically have less success in the education system compared to their native English speaking peers.

SIOP and Language Objectives

While all students struggle with the burden of learning academic language in school, ELLs are also tasked with learning of conversational English language. Even with a high level of conversational English, ELLs struggle on school assignments and state assessments. The lack of foundational skills in English hinders student learning throughout school, and inhibits success on the standardized testing that is required for graduation in many states. To address the need for students to learn both academic language and English language together, in 2003 Echevarría, Vogt and Short created a set of guidelines for teachers to follow. The guidelines have eight broad categories that encompass a total of 30 specific features (see Table 1). The SIOP model has been used by

teachers to make their content more accessible for all students (Echevarría, Vogt, & Short, 2008).

When used in everyday classroom instruction, the SIOP model helps to improve lessons by focusing on the development of academic language. While most teachers are successful in creating content objectives for what students are expected to know by the end of a lesson, teachers who implement SIOP also create language objectives that specify what students will need to learn by the end of each lesson to enhance their English language repertoire and abilities. Language objectives can be broken into four main categories; 1) academic vocabulary, 2) language functions and skills, 3) language structures and grammar, and 4) language learning strategies (Echevarría & Short, 2016).

Table 1
SIOP Guidelines and Features

Lesson Preparation	Building Background	Comprehensible Input	Strategies	Interaction	Practice/ Application	Lesson Delivery	Review and Assessment
1. Content Objectives	7. Concepts Linked to Students' Background	10. Appropriate Speech	13. Learning Strategies	16. Frequent Opportunities for Interaction	20. Hands-On Practice	23. Content Objectives Clearly Supported by Lesson Delivery	27. Key Vocabulary
2. Language Objectives	8. Links between Past Learning and New Learning	11. Clear Explanation of Academic Tasks	14. Scaffolding Techniques	17. Grouping Configuration	21. Application of Content and Language Knowledge in New Ways	24. Language Objectives Clearly Supported by Lesson Delivery	28. Key Content Concepts
3. Appropriate Content Objectives	9. Developing Key Vocabulary	12. A Variety of Techniques Used	15. Higher-Order Questioning	18. Sufficient Wait Time	22. Integration of All Language Skills	25. Students Engaged Approximately 90-100% of the Lesson	29. Regular Feedback on Student Input
4. Supplementary Materials				19. Clarify Concepts in L1		26. Pacing of the Lesson Appropriate to Students' Ability Levels	30. Assess Student Comprehension of Objectives
5. Adaptation of Content							
6. Meaningful Activities							

Academic vocabulary can be general or subject specific, and could include any vocabulary that students may need to comprehend the topic and content objectives. When instructing students on academic vocabulary, teachers should consider looking at not only content vocabulary, but also vocabulary that can be applied cross-curricular or directive words such as “explain,” “compare” or “hypothesize” (Echevarría & Short, 2016).

The remaining three categories that are included in language objectives are equally critical for student success, but have the tendency to be ignored in many elective

classes. The need for students to have language learning strategies, to constantly improve language skills, and for students to know functions structures and grammar is of utmost importance in today's global society (Echevarría & Short, 2016).

ELLs Challenges

David A. Sousa (2011) explored the theoretical aspect of teaching ELLs on a scientific level. Beyond just learning a new language, Sousa detailed the primary challenges that ELLs face in learning different subject matters and some strategies that an instructor can use to overcome the difficulties. In a technology education environment, students are expected to learn and apply both math and science in real-life scenarios. For ELLs, one of the most significant obstacles in learning math and science is gaining an understanding of academic vocabulary. Many English words used in math or science have multiple meanings. For example, in mathematics or science a “table” is generally a visual representation of data, yet many ELLs may think of the word “table” as a piece of furniture. If an instructor begins the lesson by discussing items in the table, the ELLs may spend the class trying to relate the numerical representation to a piece of furniture and thus be confused throughout the lesson (Sousa, 2011).

Another consideration when teaching ELLs are the cultural differences that may exist between the United States perception of Science, Technology, Engineering, and Mathematics (STEM) and the ELL's culture. To address these difficulties in a STEM classroom, instructors can take time to teach specific vocabulary, frequently monitor learning, and provide access for language competencies (Sousa, 2011).

SIOP Rational

There are many different theories that exist for the rational of implementing the SIOP model. The theories tend to build off each other, and offer a clear rational for implementing language content standards. To determine if the theories are addressing how a student is acquiring a new language, Echevarría and Graves urge the teacher to conduct frequent self-reflections about their own teaching. The following questions should be considered (Echevarría & Graves, 2007):

1. What are the assumptions underlying the approach I am using?
2. Do these assumptions apply to my students?
3. Do I obtain my desired outcome using this approach?

To get started implementing the SIOP model (or to continue implementation) numerous resources are available to guide teachers through the many features and components. Many of the strategies are typically already being employed in Career and Technical Education courses. For example, due to the nature of most technology education curriculum, and the training in safety and fabrication techniques that technology education teachers have, students are generally working on “hands-on practice” (Feature 20 of SIOP) or the teacher has planned for “meaningful activities” (Feature 6 of SIOP) through real-world applications.

There are many teaching strategies that are helpful in creating a technology education environment where both ELL students and native English speakers can thrive. Herrell and Jordan (2012) explained that predictable routines and signals can help reduce stress and make learning easier for students. A check-list can be an effective way of

monitoring students' behaviors and clarify whether a student is able to establish a routine. Another aspect of implementing SIOP that is generally already applied to a technology education course is the "[use of] authentic projects to integrate content knowledge" (Herrell & Jordan, 2012, p. 234).

Certain SIOP strategies are introduced specifically for lesson preparation that address creating objectives. Sometimes it becomes necessary to take a break from a content oriented lesson and have a lesson that is focused on language acquisition. Also, a well-planned language framework "provides a vital link to the difficulties many English language learners experience" (Herrell & Jordan, 2012, p. 131). The reoccurring act of determining a student's level of English can help determine the framework for which the language objectives should be set (Herrell & Jordan, 2012).

SIOP Studies with ELLs and ESL students

The SIOP model's level of success has been confirmed through many studies. From 2004-2006 a quasi-experimental study was performed to measure the SIOPs effects on secondary student performance. The study was conducted in two New Jersey school districts (one served as a treatment school district and the other functioned as a comparison school district) (Short, Echevarría, & Richards-Tutor, 2011).

First, researchers from the Center for Applied Linguistics used a five point SIOP rating scale to determine the extent at which the teachers in both districts adhered to using sheltered instruction. In the treatment district, teachers were given a year of professional development to improve sheltered instruction techniques, and by the second year, 71% of teachers were deemed "high implementers" of SIOP. In the comparison

school, only five percent of teachers were ranked as “high implementers of SIOP by the end of the study” (Short, et al., 2011, p. 369).

Next, student test scores in oral language, reading, writing and total English proficiency were collected from both school districts. The data showed that students who had at least one SIOP teacher had statistically significant improvement in the areas of oral proficiency, writing proficiency and total English proficiency compared to students who did not have SIOP trained teachers. In this New Jersey study, data was also collected for other content areas. While “the content achievement results indicate some promise for the SIOP Model,” the sampling for each content test was deemed too small to validate the data (Short, et al., 2011, p. 371).

SIOP studies with Non-ELL or ESL students

In her 2009 study, Jennifer L. Collins implemented the SIOP model into her 5th grade elementary education classroom to increase student achievement. Collins’ classroom did not have an abundance of ELLs, however she found that by integrating SIOP into her class, African American students became more successful in acquiring academic language.

In Collins’ classroom, the unit began by asking each student an arrangement of questions about their previous learning experiences, and how the students learned. At the end of the year, students were asked similar questions that also included the students’ feedback on lessons from the year of SIOP implementation and how the SIOP model year was different from previous learning. Students were also asked to reflect on specific

lessons to identify standards, and to record what they learned in personal journals (Collins 2009).

Collins's study found that as a specific student's academic language improved, peers were more likely to approach the specific student for help which led to increased self-confidence. Per Collins, "the qualitative analysis of the data [from the study] revealed academic growth in the students who participated" (2009, p. 116). Furthermore, quantitative data from 10 students revealed all students who participated in the SIOP implementation research project showed growth in both mathematics and reading. Collins also concluded that in addition to fostering academic language growth, SIOP "provided a structure for purposeful collaboration and cooperation" (2009, p. 117).

Summary of Conceptual Framework

In the United States school systems, there is a growing number of students who are classified as having English as a second language, or are considered English language learners. For ELLs or ESL students, conversation and academic English skills are generally lower than their native English speaking peers, which attributed to lower student achievement. To help overcome the many challenges that ELLs or ESL students face, the Sheltered Instructional Observational Protocol (SIOP) model was created as a method of instruction that makes academic content and English more accessible to students learning in second language. SIOP has 30 features that, when followed, have been shown to improve student success in improving oral skills, writing skills, and overall English proficiency. SIOP has also previously been shown to improve test scores of students who are not classified as ELLs or ESL students. The 30 SIOP features

includes defining a language objective to correlate to the content objective for each lesson.

METHODOLOGY

Introduction

For my classroom research project, I studied how employing language objectives in a technology education course impacted student achievement. In my classroom, students frequently struggle with academic or technical language. It was my hope that by defining language objectives, my students' technical language skills would improve, and consequently impact achievement, encourage positive peer relationships, increase confidence and increase interest in engineering or other STEM fields. This classroom research project observed the effect that language objectives had on students' ability to learn content material, as well as the effect on student interaction and collaboration, student confidence in STEM topics, and student interest in STEM.

Treatment

To study the effects of the lesson preparation component of SIOP, I implemented Feature 2: "Clearly defined language objectives" of the SIOP model into my technology education classroom and collected data via the instruments in Table 3. The classroom research project took place over the course of three months, and covered two units of study. Each unit was divided into two phases; a design/research phase and building/hands-on phase. The first unit covered structural engineering and required students to design and build a box girder beam bridge out of balsa wood. The second unit required students to research, design and construct a chair from a limited supply of

cardboard. During treatment, language objectives were visually displayed on the chalkboard and a copy of the objective calendar was linked in BlackBoard for students to access (Appendix A). This classroom research project was started by implementing the box girder beam bridge structural design phase with treatment, followed by building the box girder beam bridges without treatment, and then the order was flipped to the cardboard chair design unit without treatment and a unit build the cardboard chairs with treatment to see if there was a correlation between units with language objectives and students' achievement, behavior, and confidence.

Participants

This classroom research project was performed in two sections of a Career and Technical Education elective called Introduction to Engineering Technologies. Section A of Introduction to Engineering had 18 students (capacity of the classroom is equal to 18) and consisted of 17 male students and 1 female student. Section B contained 15 students, all of which were males. School wide, 6.12% of students qualify for the free or reduced lunch program. The Introduction to Engineering Technologies course is a general education class, and contains students of varied academic levels and abilities. As a general education elective, students are also of varied motivational levels. Some students take the Introduction to Engineering Technologies course to fulfill a practical art graduation requirement, while others choose to take the course because of interest in the content area. Over all, most students enrolled in the course are average students, with some less motivated or special education students and a few high achieving, highly motivated students. While 30 students identified as speaking primarily English at home, 3

students converse in a language other than English with their families. A closer look at the classroom demographics can be seen in Table 2.

Table 2
Classroom Demographics

		Number of Students	Percent of Sample
Grade	9	18	54.5%
	10	7	21.2%
	11	3	9.1%
	12	5	15.2%
Gender	M	32	97.0%
	F	1	3.0%
Ethnicity	Asian	1	3.0%
	Black	2	6.1%
	Hispanic	2	6.1%
	Multiracial	1	3.0%
	White	27	81.8%
<i>Total</i>		33	100%

Data Collection Methods

To measure the impact of implementing the lesson preparation component of the SIOP model in technology education, I collected data via classroom observations, formal interviews with students, a student objective journal, student surveys, and students' achievement on assessments. To ensure my action research was both valid and reliable, I used at least three instruments to triangulate data for each research question. Numerous colleagues helped develop the instrumentation and reviewed completed instrumentation, and some tools were found online and modified to better suit the project's needs.

Table 3
Focus Questions with Instruments

Research Questions	Classroom Observations	Formal Interviews	Student Journals	Student Surveys	Formative assessment
What effect does implementing “Feature 2: Setting Language Objectives” of the Lesson Preparation component of SIOP in a technology education environment have on students’ achievement?	X	X	X	X	X
In what ways does clearly defining language objectives impact students’ mastery of content material in a technology education class?		X	X	X	X
In what ways does clearly defining language objectives impact student engagement with peers in a technology education class?	X	X		X	
How does increasing technical language impact student confidence in science, technology, engineering and mathematics?		X	X	X	
How does increasing technical language impact student interest in pursuing further opportunities in science, technology, engineering and mathematics?		X	X	X	

Classroom observations

Classroom observations were completed using an Observational Checklist based on a “Self-Check Behavior Checklist” generated from the Intervention Center website. The objective of the classroom observational checklist was to gauge students’ peer interactions while working independently and in groups, so all categories were targeted towards how students collaborate with each other as well as respond to the instructor. The checklist contained common behaviors associated with being unengaged in the lesson, as well as negative behaviors exhibited when students were collaborating in a group. The

observational checklist also included an area where the content and language objectives could be recorded, as well as the date observed. A copy of the observational checklist can be found in Appendix B.

Formal Interviews

During treatment implementation and posttreatment, formal interviews were conducted with students. A total of five students participated in interviews, or approximately 15% of participants. Participants were selected using a random student generator in PowerSchool. During the formal interviews, students were asked seven questions that covered all four research questions (Appendix C).

Student Journals

Student journaling was implemented via BlackBoard's journal feature. The journals were assigned three to four times a week, and had a different prompt for each entry. Students were responsible for answering questions that showed mastery of the objectives, summarize progress, or raising concerns about the objectives or coursework.

Student Surveys

Prior to treatment, during treatment, and after treatment, Google Forms was used to gain an overview of students' progress and thoughts. While the student journals were meant to be a formative assessment, the student surveys served to get more specific information from students. The initial Action Research Student survey (ARS1) had multiple sections that addressed each research question (Appendix D). The data from the student survey served as a baseline on students' thoughts on their own achievement and abilities to communicate effectively prior to any treatment. After every few questions the

survey contained open-ended questions to gather qualitative data for students to express themselves and explain their perceptions.

A second Action Research Student survey (ARS2) was administered to students during treatment. The ARS2 was administered at the end of January, so that students were familiar with language objectives. The ARS2 collected demographic information, and gauged students' perception of the course. Students were asked about the effects of content and language objectives, as well as communication skills (Appendix E).

The final Action Research Survey (ARS3) was administered to participants after all treatment was implemented. The ARS3 inquired about how peer interaction changed, and if students' confidence and interest in STEM changed after the treatment (Appendix F).

In the analysis of all three surveys, when presented with Likert Scale survey questions, responses of "Very likely/Strongly Agree/5" or "Likely/Agree/4" were grouped together, due to the range of personal opinions that impact the distinction between being "very likely" versus "likely." Likewise, responses of "Not at all likely/Strongly Disagree/1" or "Unlikely/Disagree/2" were combined.

Assessments

Finally, student achievement in the content area was documented on multiple assessments. In class, students worked through the engineering design loop on a structural design unit and a cardboard chair unit. In both units, students started by conducting research/brainstorming and creating a computer aided drafted design using AutoDesk Inventor®.

For the structural design unit, students designed a box girder beam bridge, generated a drawing file and then reviewed their peers' drawing files. Students used the peer feedback to make revisions before building model bridges with a partner. The cardboard chair unit was completed after the box girder beam bridge. First, students performed research about anthropometrics, compiled research on existing chair designs, and created sketches. During the second part, students designed their chair in AutoDesk Inventor[®]. Students built a model chair from cardstock, critiqued the models, and then made modifications to the design before building a full-sized prototype. There were five assessments used to collect data for each unit. For each unit, three of the assignments were graded based on completion, and two assignments were graded based on accuracy or efficiency.

Bridge Design-Brainstorming. To brainstorm possible bridge solutions, students used a free to download program, from bridgecontest.org, called "Bridge Designer 2016" to electronically design three different style bridges, and then used a simulation that allowed students to test their designs. Once students had a successful design, students took screenshots of their bridges to turn it in. This assignment was graded based on completion, and points were deducted for late work or missing solutions.

Bridge Design-Peer Review. Students provided written feedback and made corrections on a peer's bridge drawing file. This assignment was graded based on completion.

Bridge Design-Final Drawing File. Students made all applicable corrections and improvements to the peer reviewed drawing file, and submitted a final copy. Drawing files were graded based on a check-list style rubric.

Bridge Construction-Set-up. Students worked in groups of two to prepare a work board for construction. The bridge construction was graded based on completion, and the assignment required students to listen to directions, print drawing files to scale, and efficiently lay out a work board. Work completed after the due date was penalized.

Bridge Construction-Results. Students worked in groups of two and were required to take measurements of their bridge, record their data, and then test their bridges to failure. After obtaining all data, students calculated bridge efficiency. This assignment was graded on a performance curved based on efficiency of bridge designs.

Chair-Research. Students were provided with a list of research questions to answer. Students then participated in a class discussion to review answers. This assignment was graded based on accuracy.

Chair-Brainstorming. Students brainstormed 10 different possible chair ideas, and wrote a short description of each idea. This assignment was graded based on completion, and late work or missing designs were penalized.

Chair-Sketches. Students selected three of the 10 ideas, and created detailed sketches with dimensions and necessary annotations for construction. This assignment was graded based on completion. Late work was penalized.

Chair-Model. Students worked in groups of two and printed out a scaled drawing file for all parts, and then constructed a $3/32'' = 1''$ model. This assignment was graded based on completion. Late work was deducted points.

Chair-Prototype. Students worked in groups of two and plotted a 1:1 scale drawing file for all individual parts, and then used drawing files as patterns to construct a functioning prototype. This assignment was graded on a performance curved based on efficiency of chair designs.

IRB Exemption

This classroom research project was completed at an established educational setting, with all instrumentation involved normal educational practices, educational tests, surveys or interviews without identifying any human subjects. As such, an exemption waiver was obtained from the Institutional Review Board at Montana State University and compliance for working with human subjects was maintained (Appendix G). This classroom research project was granted administrator approval from the building principal, and the superintendent of schools (Appendix H).

DATA AND ANALYSIS

Perception of Content

Data on student perception of content material was collected using a student journal, the ARS2, assessments and formative interviews. The data collected served to address if students were able to better perceive content and learn material more effectively when language objectives were applied in the classroom. Assessments for design units were graded out of five points, while assessments for building were graded

on a 10-point scale. All grades were then converted to percentages, and class averages were calculated. Participants earned an average of an 89% when working on assignments with learning objectives, while assignments without learning objectives had an average score of only 84%. Grades on the structural engineering units were overall higher than the cardboard chair unit. The percent change on formative assessments was calculated by dividing the difference between the mean assessment scores (with treatment and the mean assessment score without treatment) by the mean assessment score without treatment. During the design units, student performance increased by 15% when language objectives were introduced. However, for hands-on units with building components, students performed slightly better without treatment, as reflected in Table 4.

Table 4
Formative Assessment Performance

	With Treatment	Without Treatment	Percent Change
<i>Design Units</i>	92%	80%	15%
<i>Building Units</i>	85%	89%	-4%
<i>Overall</i>	89%	84%	5%

Note. (N=33)

On the ARS2, participants were asked whether or not it was easier to work with content and language objectives written on the board. Out of 31 responses, 19 students identified as performing better with content objectives written on the board, yet only 12 students felt the same about working with language objectives. For students who liked having both content and language objectives written on the board, some explanations included “It helps me stay organized,” “it is like a checklist for me to use every day,” or “because I won’t ever forget what I need to do.”

Five participants said content objectives being written on the board did not help learning, and seven students identified as not finding language objectives helpful at all.

Of the students who were not helped by the content and language objectives, students said that having both objectives was “difficult because [there were] too many things to do at once” or that “there are no tips on the board to help us with that [learning] objective.” In Table 5, data from the student responses indicated students were much more likely to find content objectives helpful, compared to language objectives.

Table 5
Students’ Opinion of Working with Content and Language Objectives Written on the Board

	Content Objectives	Language Objectives
<i>I find it is more difficult to work</i>	16.1%	22.6%
<i>It is not easier or more difficult to work</i>	22.6%	38.7%
<i>I find it is easier to work</i>	61.3%	38.7%

Note. (N=31)

When asked during student interviews, all students indicated that by using language objectives, it helped them to learn and perceive content. During the treatment, three students were asked a total of seven questions (Appendix C). When specifically asked “when [the instructor] set learning objectives, how did you perceive the content,” students responded in a positive manner. The first student interviewed said, “I know how to do it better,” and a second student indicated that it was easier to look up online when learning objectives were specifically taught. A third student went into more details and explained that learning objectives “helped me learn a little. Because I am not much of a visual learner, if I hear something, I can picture it better.” All three students discussed how the objectives enabled them to perceive the content more effectively. During the posttreatment interviews, students also indicated that they could perform better when having to write down ideas and follow written language objectives. One student explained that by writing down the language objectives, they could stay on track and set

more specific goals for oneself. Another student's response was similar in that they felt "it helps you categorize your thoughts and people don't think you're crazy" when you are working with a partner.

When looking specifically at how successfully students performed academically with language objectives, the qualitative data shows improvement during a design phase, but no improvement during building or hands-on units. Setting language objectives helped students to perceive content during the design or research stage of the units, when typically students work independently. During hands-on, collaborative learning, which requires students to interact with a partner, language objectives had no effect on whether students learned content more effectively.

Peer Interactions

Only two students were identified as having less opportunities to communicate in the Introduction to Engineering Course compared to other classes. Twenty-two students, or 71% of students surveyed on the ARS2, indicated that the Introduction to Engineering course allowed for more opportunities to interact with their peers compared to a typical classroom. From the ARS1 to the ARS3, a large portion of students' responses shifted in regards to how well students felt they were able to explain themselves to a peer, ask a peer for help, or ask the instructor for help. The percent change was calculated by dividing the difference of survey responses by the initial survey response. After treatment, there was a 74.45% increase in the number of students who would ask a peer for help when troubleshooting (Table 6). Initially, when asked whether students would ask a peer for help, student responses were varied, however after the classroom research

project concluded, there was a significant increase in the number of students who would be willing to ask a peer for help.

Table 6
Students' Option on the Likelihood of Asking a Peer for Help

	ARS1	ARS3	Percent Change
<i>Disagree</i>	30.3%	16.1%	-46.8%
<i>Neutral</i>	36.4%	25.8%	-29.1%
<i>Agree</i>	33.3%	58.1%	74.4%

Note. (On ARS1 $N=33$, and on ARS3 $N=31$)

According to the student surveys, after treatment, students were more likely to indicate they would not help a peer, that they preferred working independently, and that they were not successful in helping their peers learn. A full comparison of survey responses about peer interactions can be seen in Figure 1. While it seems contradictory, students were more willing to ask for help and yet more resistant to helping each other. Students identified the difficulties with helping their peers mostly in three areas; understanding the peer's question, not knowing the answer, or lack of peer "cooperation."

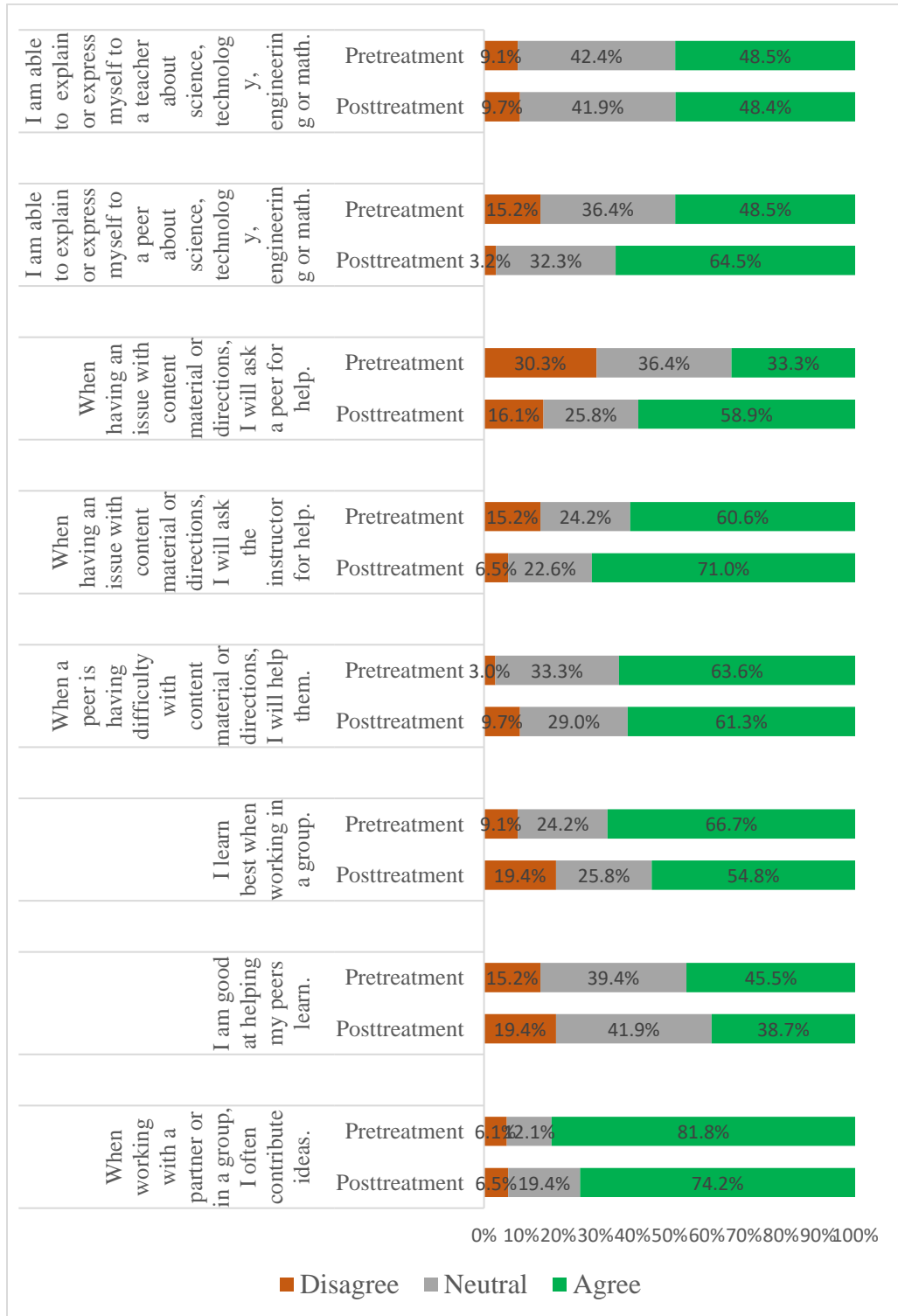


Figure 1: Student responses taken from ARS1 and ARS3 surveys: Part 1, (N=33, N=31).

Classroom observational data showed that when language objectives were implemented in the classroom, students were more likely to be involved in an off topic conversation regardless of whether they were in a build or design phase. An average of 13 students held off topic conversations when language objectives were set, compared to 9 students per lesson who would hold side discussions without language objectives being set. In a lesson that is structured around student interaction and collaborative learning, when giving the students specific topics to discuss, students were more likely to stray onto topics that were not associated with the class content. Students were also just as likely to speak loudly when having a discussion with peers, regardless of language objectives (see Table 7).

Table 7
Summary of Classroom Observations

	<i>With Language Objective</i>	<i>Without Language Objective</i>
Percent of students talking across the room		
<i>Design Phase</i>	7%	11%
<i>Build Phase</i>	10%	12%
Percent of students not involved in class discussions		
<i>Design Phase</i>	9%	17%
<i>Build Phase</i>	9%	10%
Percent of students holding off topic conversations		
<i>Design Phase</i>	40%	27%
<i>Build Phase</i>	47%	32%
Percent of students speaking in a loud voice		
<i>Design Phase</i>	5%	2%
<i>Build Phase</i>	9%	9%
Percent of students who ask peers for help		
<i>Design Phase</i>	45%	9%
<i>Build Phase</i>	79%	85%
Percent of students who ask instructor for help		
<i>Design Phase</i>	12%	26%
<i>Build Phase</i>	18%	10%

Note. (N=33)

When language objectives were set during a design or research phase, and during building or collaboration phase, classroom observations showed students were less likely to talk across the room with another student. Students were also more likely to be involved in group discussions when language objectives were set. Specifically, during the design phase, 17% of students were not involved in class discussions when no language objectives were set. This 17% of students had heads down, or were on an electronic device. When language objectives were set, only nine percent of students exhibited the same behavior. The increase in attentiveness during class discussions when language objectives were set in the design setting was much more profound than during a building phase, when only ten percent of students were not involved in discussions. The observational checklist data shows that language objectives had a profound effect on student attentiveness during class time that was spent working independently, and only a slight difference when students worked with peers, in groups of two, to build projects.

Finally, looking at the observational checklist data, students were significantly more likely to ask a peer for help when language objectives were set during the design phase. Only nine percent of students asked for help during the design phase without treatment. Once language objectives were implemented during design phases, the number of students who asked a peer for help jumped to 45%. The same was not true for students seeking help from a teacher. The number of students who asked the teacher for help decreased from 26% to 12% when language objectives were set. By setting language objectives during the design phase, students engaged more with peers, and engaged less

with the teacher, making for a more student centered learning experience. For a complete look at classroom observational checklist statistics, see Appendix I.

As previously mentioned, when language objectives were set and students wrote out responses, one student responded to the interview and said that by having language objectives that required writing, the student felt more organized when working with peers. When asked “who are you the most likely to ask for help?,” students replied that they would first ask a peer for help, and then the teacher. During the first round of interviews, all three students said that setting language objectives helped them to work with their partner. One student explained that with language objectives set for discussion, they were able to “instantly walk up to [partners] and start talking about the project and stuff and how to work it out.”

Technical Language and Student Confidence

Many of the language objectives targeted increasing technical language for the students, so by looking at the surveys, I gauged how confident the students were about their science, technology, engineering and mathematical skills. After looking at all the open response answers, I grouped the answers based on whether they showed a student as being confident in STEM or students who lack confidence in their STEM abilities. Examples of student responses that indicate confidence versus a lack of confidence are shown in Table 8. On the ARS1, 34 different responses were considered confident, and 13 negative responses were recorded. Out of a total of 47 answers that had an indication of confidence, 72% of responses were confident. On the ARS3, when looking at the same questions, there were 35 student answers collected. Twenty-seven of the 35 responses on

the ARS3, or 77%, indicated the students were confident in their STEM abilities. With a five percent difference in number of responses, the student survey data showed some evidence of students being more confident in STEM after being exposed to more technical vocabulary through the use of language objectives.

Table 8

Examples of Student Responses that Indicate Confidence.

Student Responses With Confidence	Student Responses Without Confidence
“Because I get amazing grades when it comes to those fields”	“Because I think I am average in it”
“I gave myself a high rating because I am in advanced classes for math and science, and have always done well in these courses.”	“Because there are something’s I have trouble with in math”
“I feel that I can because I find these subjects easy”	“I’m still learning”
“I’m gifted in math and love technology”	“Because computers sometimes confuse me”
“I am good in math and it’s my favorite subject”	“I have trouble with science sometimes”
“Cause I’m good at them”	“I had to get better in that”

When asked on a Likert scale question to agree or disagree with the statement “I am confident in my abilities in science, technology, engineering and mathematics,” no students shifted from any categories. The change in percentage from the first survey to the last survey was reflective of the different number of participants. Both surveys showed three students rating themselves as “disagree,” and 10 students as “neutral.” However, when asked to indicate their confidence in *learning* STEM, 74.2% of participants said they were confident in their abilities after treatment, compared to only 57.6% of students prior to treatment. A comparison of specific questions from the pretreatment to posttreatment can be seen in Figure 2.



Figure 2: Student responses taken from ARS1 and ARS3 surveys: Part 2, (N=33, N=31).

When asked in the first round of student interviews if language objectives influenced the student’s confidence, two out of three students identified as being more confident as a result of the language objectives being set. One student explained “because

it just did, when you gave more directions it made it more simple, more clear to understand, and I knew what to do better.” Another student said they were more confident “because it taught me shear and stress and tension” (terms used when building the bridge). The student explained that by knowing more about what was physically happening, they became more confident in the civil engineering content. The third student responded “I guess a little bit,” and was unable to provide more details.

Prior to implementing treatment, students were more likely to show a lack of confidence in their abilities as reflected in their journals. Journal entries from before treatment frequently included comments such as “I don’t remember when or how to use it” or a simple “I don’t understand.” After treatment, students were much more likely to respond to the journal prompts, as well as say good things about their projects. Students reported that their projects went “pretty well,” “very well” or made concrete suggestions for improvement, such as “our bridge did well but one thing we would have changed was making our cross sections stronger.” Compared to pretreatment journal entries, student responses were more specific, and over-all more positive.

After language objectives were implemented into the classroom, students indicated that they were more confident in learning the material. During interviews, students also indicated that by using language objectives, they felt more confident in how well they learned. After analyzing journal entries, I found similar patterns across journals that showed without learning objectives, students would use their journals to write generic questions, or say what they could not accomplish. After language objectives, students were much more specific, hopeful, and optimistic about the content. This change

in journal writing may be attributed to a higher level of comfort journaling, however responses from the student surveys as well as the interviews supporting an increase of confidence in abilities to learn, I feel that the more detailed and positive entries were an implication of the use of language objectives.

Technical Language and Interest in STEM

Data from the student ARS1 and ARS3 surveys showed little change in students' interest in pursuing further opportunities in STEM. Any change in percentage for the statement "I plan to continue to learn and/or take another elective class in science, technology, engineering and mathematics" (shown in Figure 2) reflected the change in number of participants between surveys.

In student interviews, there was no connection established between interested in STEM careers and language objectives. While students did indicate an interested in engineering and building, reasoning for their interest were not supported by implementing language objectives. Likewise, insufficient data was available from journals on Blackboard. Student entries did not show any connections between technical language and interest in STEM.

INTERPRETATION AND CONCLUSION

In this classroom research project, when language objectives were clearly defined, students' perception of the content material was impacted. Student performance on assessments increased an average of five percent when working on units with language objectives. Language objectives had a more profound effect on achievement during traditional units, such as design, compared to hands-on, building units (15% change

versus -4% change, respectively). Many students found that having both language and content objectives were helpful in learning content (“it helps me stay organized” or “because I won’t ever forget what I need to do”).

Clearly defining language objectives also had an impact on student engagement with peers in the technology education classroom. During the design phases, when students were generally working independently, language objectives dramatically changed the likelihood of students asking peers for help. By using language objectives during the design phase, students were 74.4% more likely to seek help from their peers, and students were more likely to be engaged in class discussions compared to the unit without language objectives. As for group work and collaborative building, students were less likely to ask a peer for help, as well as less likely to stay on topic during conversations. Building and constructing projects peaks student interest regardless, and by adding a new layer of complexity with language objectives, some students were more likely to hold discussions about irrelevant topics.

By setting language objectives and increasing technical language, students became more confident in their abilities to learn STEM concepts. Initially only 57.6% of students identified as being confident in their abilities to learn, but, posttreatment, the number increase to 74.2% of students. By setting language objectives during the design phase (while working at desks), students participated in more techniques for learning, and became more confident in their abilities to learn new information.

While the study intended to show a connection between increasing technical language and students being more confident, engaged, and interest in STEM and STEM

careers, I was unable to obtain data that supported the hypothesis, and would conclude that there is no correlation between increasing technical language and student interest in pursuing further opportunities in science, technology, engineering and mathematics.

Overall, by using language objectives during the design phase, students' formative assessments and classroom observations showed academic achievement improved and that students collaborated more with peers. In a technology education class, students regularly collaborate on group work, and during group work, this classroom research project found language objectives had little impact on student achievement. However, when used in design units, or a more traditional classroom, findings of this classroom research project suggest that students performed better with content, were more engaged with peers, more likely to seek help from peers, and had more confidence in their abilities to learn the content.

Out of all the findings from this project, I feel the fact that students were more confident in their abilities in learning STEM with increased technical language was the most beneficial finding to my classroom. In a world with a growing demand of individuals in STEM careers, any bump in potential technological literacy is advantageous, not to mention the benefit to students in any field of study. If by implementing language objectives, students grow more confident in their ability to learn, teachers will be able to help even the lowest achieving students more effectively.

Language objectives, and the rest of the Sheltered Instructional Observational Protocol, are fantastic tools to help students who are learning English as a second language, but language objectives are also effective when used with regular education,

special education, or even honors level students. As technical language improved, as with academic language in Collins's study, students were more likely to approach peers for help, and there was improved communication between individuals.

VALUE

Through the careful planning and implementation of this study, I have grown tremendously as a teacher. This classroom research project required countless hours of professional development in working with ESL and ELL students, as well as studying SIOP and SIOP implementation. Every year in my engineering courses, I start by reviewing basic math skills and how to use a ruler. Generally, the review starts off with students struggling, but after a few minutes students rapidly remember the rules of adding and subtracting fractions. Before beginning my classroom research project, I had a student who was struggling. I tried all the usual tips and tricks, and it took about 20 minutes of one-to-one instruction before I realized the specific student was an ESL student, and had previously only used metric measurements. It was such a small change, however, as soon as we realized the problem involved interpreting the lines as measurements of a base ten unit rather than a base two, the student was able to successfully complete the assignment. In my classroom, I was lucky enough to be able to work with him to fix the misconception, however, in other classes, the student would be lost in a room of 20 or 30 students. For such a small misunderstanding, if not addressed, the consequences for the rest of the year could have been dire.

Implementing language objectives is one small way to help these students with the tremendous task of learning academic language on top of conversational English and

culture. Throughout the future of my career as a teacher, and my life outside of school, the skills and abilities I have learned by researching SIOP are of unsurpassable value.

More specifically, by setting language objectives and having to specifically note students' behavior, I was forced to become a much more observant instructor. After using a checklist for three months, my level of "withitness" has drastically improved, as well as my level of understanding for each student. By observing a student's interactions so closely, I have been able to pick out who needs to be challenged more, and who is struggling.

This classroom research project required me to delve deeply into student journaling, and while I started off the academic year struggling with having students journal, at the end of my journey I started implementing daily journaling in all of my classes, not just those courses included in this classroom research project. Again, while it may seem like a small change, I found journals became a great place to have students synthesize what was being taught in class and reflect on ideas and learning.

My next steps, after seeing the effect of implementing language objectives, will be to work towards implementing more features of SIOP into my daily classroom routine, as well as implement language objectives into more of my classes. I feel that continued SIOP instruction would be beneficial, and after completing my classroom research project I would like to revisit the initial literature and look at how I can improve my language objectives, as well as what else I can implement and improve upon in my classroom.

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APPENDICES

APPENDIX A:
OBJECTIVE CALENDAR

JANUARY 2017

SUBJECT Intro to Engineering

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1	2 Content Objective Identify key information from design brief Language Objective Read design brief	*3 Create 3 sketches of possible bridge designs that meet criteria Discuss what "lamination" means in terms of this project	*4 Use Inventor to create individual parts of balsa wood. Write directions for how to find the length of vertical members	5 Use Inventor to create individual parts of balsa wood. Write directions for how to find the length of vertical members	6 Use Inventor to create individual parts of balsa wood. Write directions for how to find the length of vertical members
2	9 Content Objective Create an assembly file in Inventor Language Objective Discuss with a partner the differences between "Flush" and "Mate"	*10 Create a fully constrained cross section of a bridge Use Inventor help menu to find definition and how to use flush	*11 Create a fully constrained cross section of a bridge Write a definition of "cross section"	*12 Modify and pattern cross section to create model bridge Explain when to use rectangular versus circular pattern	*13 Modify and pattern cross section to create model bridge Explain when to use rectangular versus circular pattern
3	16 Content Objective Generate and edit a parts list for a drawing file Language Objective Discuss with a partner what the pros and cons of a parts list are	*17 Print a drawing file and proof read your work. Write improvements in your Journal.	18 Critique peer work and determine if peers' bridges meet all criteria. Assist peers in making bridge improvements. Clarify project criteria to peers Write improvements on peer's design Discuss improvements with peers	19	20
4	23	24	25	26	27
	----Midterms----				
5	30 Content Objective Use self-review, and peer review to make corrections on parts, assembly and drawing files Language Objective	31			

FEBRUARY 2017

SUBJECT Intro to Engineering PERIOD 5/8

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
WEEK 5			1 Create hypothesis for each member of your groups' bridge.	2 Select one bridge and identify areas of improvement	3 Make corrections on drawing files
WEEK 6	6 Set-up building boards	7 Watch demonstrations and assess building tools and techniques	8 Demonstrate safe use of all tools while cutting side section members	9	10 Demonstrate safe use of all tools while gluing side section members
WEEK 7	13 Demonstrate safe use of all tools and machines while building bridge	14 Demonstrate safe use of all tools and machines while building second side section	15 Demonstrate safe use of all tools and machines while assembling side sections.	16 Demonstrate safe use of all tools and machines while assembling complete bridge.	17 Demonstrate safe use of all tools and machines while assembling complete bridge.
WEEK 8	20	21 Demonstrate safe use of all tools and machines while assembling complete bridge.	22 Demonstrate safe use of all tools and machines while assembling complete bridge.	23 Demonstrate safe use of all tools and machines while assembling complete bridge.	24 Demonstrate safe use of all tools and machines while assembling complete bridge.
WEEK 9	27 Test bridge hypothesis	28 Test bridge hypothesis			

MARCH 2017

SUBJECT Intro to Engineering PERIOD 5/8

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
WEEK 9			1 Summarize key aspects of a chair.	2 List important chair measurements for the 95 th percentile.	3 Compile a list of 10 brainstorming ideas for a chair
WEEK 10	6 Create 3 sketches of possible chair solutions	7 Create 3 sketches of possible chair solutions	8 Create a model of each piece of cardboard material as parts in inventor	9 From the cardboard material, create different parts in Inventor	10 From the cardboard material, create different parts in Inventor
WEEK 11	13 Create an assembly file of the finished chair	14	15	16 Create an assembly file of the finished chair	17 Create a drawing file with parts list, balloons, and dimensions of finished chair.
WEEK 12	20 Demonstrate safety use of all tools to build a model cardstock chair Discuss with a partner how your design utilized inner locking parts	21 Demonstrate safety use of all tools to build a model cardstock chair Make a written list of changes to your design made during building.	22 Demonstrate safety use of all tools to build a model cardstock chair On your drawing file, add annotations for changes that will need to be made in your drawing file.	23 Critique your cardstock chair model, and revise your CAD files. Look at a partner's Cardstock chair. Ask them a question about their design.	24 Revise CAD files to reflect changes and alterations. Write a reflective summary of what you learned by building a model from cardstock.
WEEK 13	27 Demonstrate safe use of all tools to create a cardboard cut "mock-up" Debate with a partner the pros and cons of your design.	28 Demonstrate safe use of all tools to create a cardboard cut "mock-up" Debate with a partner the pros and cons of your design.	29 Demonstrate safe use of all tools to create a cardboard chair prototype. Discuss with your partner the directions needed for construction	30 Demonstrate safe use of all tools to create a cardboard chair prototype. Discuss with your partner the directions needed for construction	31 Demonstrate safe use of all tools to create a cardboard chair prototype. Discuss with your partner the directions needed for construction

APPENDIX B:
OBSERVATIONAL CHECKLIST

APPENDIX C:
INTERVIEW QUESTIONS

During Treatment Questions

1. Why did you take this engineering class?
2. How difficult do you think this class is? Why?
3. When I set language objectives, how did they impact the class?
4. When I set language objectives, how did you perceived the content?
5. When I set language objectives, how did you interact with peers and partners?
6. When I set language objectives, did it make you more confident in engineering?
7. What do you think you want to do when you grow up? Why?

Post Treatment Questions

1. What was more challenging, designing the bridge or the chair? Why?
2. What was more challenging, building the bridge or the chair? Why?
3. What was more challenging, communicating with your partner about the bridge or the chair? Why?
4. Do you think that by writing journal entries and having to write down your ideas, you could perform better?
5. Do you think that by talking to a partner you could perform better?
6. Do you feel that it is easier or more challenging to work with a partner now compared to the December? Why?
7. Who are you the most likely to ask for help? Why?

APPENDIX D:

ARS1

Action Research Survey

This section addresses demographics

* Required

1. What is your current grade?

Mark only one oval.

- 9
 10
 11
 12

2. Would you be willing to be interviewed by Mrs. Wong?

Mark only one oval.

- Yes
 No

Action Research Survey

This section addresses student's engagement with content material

3. I am able to explain or express myself to a teacher about science, technology, engineering or math. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

4. I am able to explain or express myself to a peer about science, technology, engineering or math. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

5. I am confident in my ability to word (or create) questions to the instructor about science, technology, engineering or math. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

6. I am confident in my ability to word (or create) questions to my peers about science, technology, engineering or math. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

7. Based on how you answered on questions 6 and 7, why do you feel the way that you do about expressing yourself and creating questions? *

8. When having an issue with content material or directions, I will ask the instructor for help troubleshooting. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

9. When having an issue with content material or directions, I will ask my peers for help troubleshooting. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

10. When having an issue with content material or directions, I will use the internet to troubleshoot or perform research. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

11. When I use the internet to troubleshoot or perform research, I am generally successful at finding answers. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

12. Why do you feel the way that you do about your success in using the internet to research? *

13. When a peer is having difficulty with content material or directions, I will help them. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

14. What do you often find is the most difficult part about helping your peers? *

Mark only one oval.

- Finding time to help them
- Understanding their question
- Knowing the answer to their question

Action Research Survey

This section addresses student's interaction with peers

15. I learn best when working with others. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

16. I am good at helping my peers learn. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

17. I often contribute ideas when working in a group. *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

18. Why did you answer the way that you did about contributing ideas in a group? *

19. When working with a partner or in a group, I often go with a peer's idea. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

20. What is the most difficult part of working with a partner or in a group? *

Mark only one oval.

- Sharing your own ideas to the group
- Taking suggestions from others in the group
- Understanding questions from others in the group
- Asking questions to the group

Action Research Survey

This section addresses student's confidence and interest in STEM

21. I am very experienced in science, technology, engineering and mathematics. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

22. Why did you answer the way that you did about your level of experience in science, technology, engineering and mathematics? *

23. I am very interested are you in science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

24. I am very interested are you in learning science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

25. I am very interested in careers in science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

26. I am very confident in my abilities in science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

27. I am very confident in my abilities to learn science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

28. I am planning on continuing to learn and/or take another elective class in science, technology, engineering and mathematics. *
- Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

29. Do you plan on pursuing a career in science, technology, engineering or mathematics? *
- Mark only one oval.

Yes

No

30. Why do you plan on pursuing (or not pursuing) a career in science, technology, engineering or mathematics? *

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APPENDIX E:

ARS2

ARS2

* Required

1. What is your primary language? (The first language you learned) **Mark only one oval.*

- English
- Other: _____

2. At home, what languages does your family speak? **Check all that apply.*

- English
- Spanish
- Other: _____

3. How would you identify yourself? **Mark only one oval.*

- Asain
- Black
- Hispanic
- American Indian
- Multiracial
- White

Course Feedback**4. How difficult do you feel the course is?***Mark only one oval.*

- 1 2 3 4 5
-
- Easy Difficult
-

5. Why do you feel the course is easy or difficult?

6. How quickly do you feel the course moves?

Mark only one oval.

	1	2	3	4	5	
Slow	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Fast

7. Why do you feel the course moves slow or fast?

8. Do you find it is easier to work when I write the content objective on the board?

Mark only one oval.

	1	2	3	4	5	
Yes-Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	No-Disagree

9. Do you find it is easier to work when I write a language objective on the board?

Mark only one oval.

	1	2	3	4	5	
Yes-Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	No-Disagree

10. Why do you find it easier (or more difficult) to work when objectives are written on the board?

11. Do you feel as though you have more opportunities to communicate in Engineering than a typical class?

Mark only one oval.

	1	2	3	4	5	
Yes-Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	No-Disagree

12. Do you feel the collaboration in the class helps or hurts you understand the content? Why?

APPENDIX F:

ARS3

AR3

* Required

1. I am able to explain or express myself to a teacher about science, technology, engineering or math. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

2. I am able to explain or express myself to a peer about science, technology, engineering or math. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

3. Why do you feel the way that you do about expressing yourself and asking questions? *

4. When having an issue with content material or directions, I will ask a peer for help troubleshooting. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

5. When having an issue with content material or directions, I will ask the instructor for help troubleshooting. *

Mark only one oval.

1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

6. Why do you feel the way that you do about asking a peer versus asking the teaching for help? *

7. When a peer is having difficulty with content material or directions, I will help them. *

Mark only one oval.

1 2 3 4 5

Disagree Agree

8. What do you often find is the most difficult part about helping your peers? *

Action Research Survey

This section addresses student's interaction with peers

9. I learn best when working in a group.

Mark only one oval.

1 2 3 4 5

Agree Disagree

10. I am good at helping my peers learn. *

Mark only one oval.

1 2 3 4 5

Disagree Agree

11. When working with a partner or in a group, I often contribute ideas. *

Mark only one oval.

1 2 3 4 5

Disagree Agree

12. What is the most difficult part of working with a partner or in a group? *

Action Research Survey

This section addresses student's confidence and interest in STEM

13. I have a lot of experience in science, technology, engineering and mathematics? *

Mark only one oval.

1	2	3	4	5		
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

14. Why did you answer the way that you did about your level of experience in science, technology, engineering and mathematics? *

15. I am interested in science, technology, engineering and mathematics. *

Mark only one oval.

1	2	3	4	5		
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

16. I am very interested in learning science, technology, engineering and mathematics. *

Mark only one oval.

1	2	3	4	5		
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

17. I am interested in careers in science, technology, engineering and mathematics. *

Mark only one oval.

1	2	3	4	5		
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

18. I am confident in my abilities in science, technology, engineering and mathematics. *

Mark only one oval.

1	2	3	4	5		
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

19. I am very confident in my abilities to learn science, technology, engineering and mathematics *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

20. I plan to continue to learn and/or take another elective class in science, technology, engineering and mathematics *

Mark only one oval.

	1	2	3	4	5	
Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Agree

21. Do you plan on pursuing a career in science, technology, engineering or mathematics? *

Mark only one oval.

- Yes
 No

22. Why do you plan on pursuing (or not pursuing) a career in science, technology, engineering or mathematics? *

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APPENDIX G:
IRB EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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 c/o Microbiology & Immunology
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Administrator:
 Cheryl Johnson
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 cherylj@montana.edu

MEMORANDUM

TO: Simone Wong and Walt Woolbaugh
FROM: Mark Quinn *Mark Quinn CQ*
DATE: October 10, 2016
SUBJECT: "The Effects of Implementing Language Objectives in a Technology Education Classroom on Student Achievement" [SW101016-EX]

The above research, described in your submission of **October 10, 2016**, 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 H:
ADMINISTRATOR APPROVAL

Administrator Approval

I, Joe Bollendorf (name), Superintendent (position) of Washington Township High School, verify that I approve of the classroom research conducted by Simone S. Wong.

Joe Bollendorf
(Signed Name, Title of Position)

Joe Bollendorf
(Printed Name)

9/24/16
(Date)

Administrator Exemption Regarding Informed Consent

I, Ann Moore (name), Principal (position) of Washington Township High School, verify that the classroom research conducted by Simone S. Wong 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 Simone S. Wong regarding informed consent.

Ann Moore Principal
(Signed Name, Title of Position)

Ann Moore
(Printed Name)

9/26/16
(Date)

APPENDIX I:
CLASSROOM OBSERVATIONAL STATISTICS

DATE	Number of Students	Talks to students across room		Not involved in discussions		Off topic conversations		Voice level is up		Does not seek help from peers		Does not seek help from teacher	
		#	%	#	%	#	%	#	%	#	%	#	%
<i>1/3/17</i>	32	4	13%	4	13%	8	25%	2	6%	27	84%	31	97%
<i>1/4/17</i>	30	3	10%	3	10%	6	20%	5	17%	15	50%	30	100%
<i>1/10/17</i>	30	3	10%	0	0%	5	17%	2	7%	11	37%	26	87%
<i>1/11/17</i>	31	0	0%	5	16%	3	10%	0	0%	21	68%	29	94%
<i>1/12/17</i>	30	2	7%	6	20%	9	30%	0	0%	17	57%	20	67%
<i>1/13/17</i>	29	3	10%	1	3%	10	34%	4	14%	15	52%	24	83%
<i>1/17/17</i>	31	2	6%	0	0%	30	97%	0	0%	13	42%	27	87%
<i>1/18-19/17</i>	29	0	0%	3	10%	26	90%	0	0%	15	52%	27	93%
<i>2/1/17</i>	30	2	7%	4	13%	1	3%	3	10%	4	13%	30	100%
<i>2/2/17</i>	32	2	6%	4	13%	0	0%	2	6%	4	13%	32	100%
<i>2/6/17</i>	31	5	16%	1	3%	19	61%	5	16%	21	68%	13	42%
<i>2/7-8/17</i>	33	9	27%	1	3%	33	100%	5	15%	0	0%	27	82%
<i>2/13-14/17</i>	29	0	0%	3	10%	2	7%	1	3%	2	7%	28	97%
<i>2/15-16/17</i>	28	2	7%	4	14%	4	14%	3	11%	1	4%	28	100%
<i>2/21-22/17</i>	30	5	17%	3	10%	10	33%	2	7%	2	7%	30	100%
<i>2/23-24/17</i>	31	5	16%	3	10%	11	35%	2	6%	2	6%	31	100%
<i>3/1-2/17</i>	29	4	14%	8	28%	13	45%	1	3%	24	83%	23	79%
<i>3/6-7/17</i>	31	3	10%	4	13%	15	48%	1	3%	24	77%	25	81%
<i>3/9-10/17</i>	27	2	7%	7	26%	8	30%	0	0%	26	96%	26	96%
<i>3/13/17</i>	28	4	14%	6	21%	11	39%	0	0%	26	93%	26	93%
<i>3/16/17</i>	30	5	17%	2	7%	0	0%	0	0%	30	100%	12	40%
<i>3/17/17</i>	29	2	7%	3	10%	0	0%	2	7%	28	97%	16	55%
<i>3/20/17</i>	33	4	12%	1	3%	14	42%	3	9%	10	30%	26	79%
<i>3/21/17</i>	31	3	10%	0	0%	11	35%	7	23%	10	32%	31	100%
<i>3/22/17</i>	32	6	19%	2	6%	8	25%	1	3%	6	19%	17	53%
<i>3/24/17</i>	33	2	6%	7	21%	1	3%	1	3%	6	18%	19	58%
<i>3/27-28/17</i>	29	2	7%	3	10%	29	100%	2	7%	4	14%	29	100%
<i>3/29-31/17</i>	29	2	7%	3	10%	22	76%	2	7%	4	14%	29	100%