An examination of how SIOP strategies can increase second language acquisition in the secondary science classroom

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AN EXAMINATION OF HOW SIOP STRATEGIES CAN INCREASE SECOND LANGUAGE ACQUISITION IN THE SECONDARY SCIENCE CLASSROOM

Kyla Plumlee

A thesis submitted in partial fulfillment of the requirements for the Master of Arts in Education Curriculum and Instruction School Of Education California State University Monterey Bay

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SIOP STRATEGIES IN THE SCIENCE CLASSROOM

AN EXAMINATION OF HOW SIOP STRATEGIES CAN INCREASE SECOND
LANGUAGE ACQUISITION IN THE SECONDARY SCIENCE CLASSROOM

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Abstract

The study compared a 110 minute intervention block, where English language learners (ELL) were taught through lessons using the Sheltered Instruction Observation Protocol (SIOP) method with a control group that received didactic lectures and inquiry labs for 110 minutes. The aim of the research was to examine the efficacy of the intervention in regards to increasing comprehension and achievement for English language learners. Students were given a pre-unit questionnaire and a post unit questionnaire, along with a unit long portfolio to assess changes in their comprehension and achievement levels. The results of this study indicated that students receiving the SIOP intervention gained a better understanding of the science lesson content, however, comprehending the multifaceted aspects of the standards was still challenging. The intervention group’s portfolio scores showed a definite increase in understanding OF academic language associated with biology compared to the control block; whereas science content understanding and ability was approximately the same for both classes, with the control group scoring slightly lower overall.
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# SIOP Strategies in the Science Classroom

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Chapter 1: Introduction

The goal of my research is to become a teacher that can help students achieve to their full potential. I want to build upon student’s base language skills within the science classroom to increase their overall achievement in their secondary education, not only their science content classroom. I choose this goal because over the last few years in the classroom I have seen students struggle with high stakes testing, writing assignments and understanding content due not to content specific knowledge, but their own personal lack of academic language skills. This is also important because, there is only a small amount of literature on the subject currently, and as our country and state become more highly populated by second language learners these skills need to fostered more and more for students’ academic success. Success is seen as student increase their California English Language Development Test (CELDT) scores and improving their ability to use their English language skills in everyday as well as academic settings.

Problem Statement

Over the last two years of teaching science the subgroup that has struggled with has been my English language learners (ELL). This year, my sophomore biology ELL students have already shown a low level of understanding of academic language used within the classroom. I also want to be able to create an environment where I can foster both science content and language acquisition using science topics. This is so they can increase their ability to achieve highly both in biology class and in state testing. These skills will be needed as students continue their secondary education and will create a base of language skills that will allow them to do well in not just my course, but in college and the work place in the future(Shanahan & Shanahan, 2008; Zygouris -Coe, 2012).
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The issue with student’s lack of second language acquisition within the secondary science classroom is leading teachers to simplify language demands in the classroom for all students. As the common core standards are implemented students will be expected to know how to use language that was rarely used with them in the lower elementary grades and will struggle to understand what even the basic questions are asking, due to academic words rather than the lack of content knowledge. Students will be required, no matter their language levels, to comply with common core testing and required to use language that goes beyond just content vocabulary. This leads us, as teachers, to become more than just content instructors, but also language instructors for all our students (Shanahan, T., & Shanahan, C; 2008).

In middle school and secondary science classrooms today students are expected to be able to read, write, and speak on an academic level, but this assumption is not being met (Collier 1987, Cummins 1981a, 1981b, 2007, and Shannon and Shannon 2008). Therefore, there is a need for research to focus on how secondary students can build academic SLA within the high school classroom science setting so that students can achieve no matter their language designation.

Purpose of Study

In this study I will be examining student’s personal comprehension of the science standards and academic language in two biology classrooms. One of those class rooms will receive the SIOP model intervention and the other class will use a more traditional didactic method combined with labs. To gage students understanding I will give a pre-unit questionnaire and post unit questionnaire using open ended questions and Likert scale. An example would be, “Rank yourself on how well you feel you comprehend this standard.” Students then had the option to choose between one and five; where a one was strongly agreed that they comprehend
the standard or a five, which meant they strongly disagreed and that they did not know the standard at all.

Over the course of the four week study I will gage student’s actual comprehension by having them create a comprehensive unit portfolio showing their growing understanding of the genetics unit and the academic language associated with the lessons. They will be graded using a teacher based rubric consisting of seven sections: organization, content information classwork, content information labs, content information final project, academic language classwork, academic language labs, and academic language final project. At the end of the unit I will choose six students to participate in a ten question interview to elaborate on their answers to the questions in the questionnaire and give further details as to how they felt the intervention or lack of intervention helped them grow or not.

Research Questions
Within the context of my action research project I propose the following questions:

- How do students who were taught science using SIOP strategies perceive the usefulness of those strategies for helping them learn to:
  - Understand and use scientific academic language; and
  - Master the science content in the unit?

- How has my teaching been affected as I implement the SIOP model into my classroom lessons and planning?

Theoretical Model
Since the mid-sixties second language acquisition (SLA) has been being examined across the disciplines of education, cognitive psychology and linguistics. This is the study of how one learned a secondary, or beyond, language. Though SLA is a fairly new broad-based academic
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discipline it has been changing drastically since it first began being examined. Vygotsky said that, "learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions" (1978, p. 35). His social development theory stresses that interaction between learners is a key component of how they learn, along with being places with a more knowledgeable other, such as a teacher or peer, and understanding learner’s zone of proximal development (1963). This theory allowed Bruner and Krashen to explain how we learner second languages. Bruner’s research led him to create the concept of scaffolding instruction for all students due to the three modes of representation. Bruner’s creation of scaffolding were based on his thoughts on how social interaction allowed language development. The theory of social interactionism explains that students need to interact with peers who speak the new language and be exposed to all aspects of the new language to obtain it (Bruner, 1963).

In the 1970’s Krashen’s (1977) input hypothesis incorporated his five theories of language acquisition that deal with the amount that second language learners are exposed to spoken and written work is the only way they can obtain the new language. Though Krashen’s input hypothesis has great merit it has a lack of connection for acquisition and learner that is very evident in any classroom. Around this time Cummins (1981b) also brought to attention the how students were able to communicate with Basic interpersonal communication skills (BICS), but were not able to communicate using cognitive academic language proficiency (CALP) or understand language that was used from this category. Cummins’s BICS and CALP theory places a demand on teachers to not just have students speak in the classroom but to have students begin to examine and properly use academic language.
These theoretical models helped me create a study that is well rounded. Without understanding Vygotsky’s ZPD, I would not have been able to create a curriculum that allowed for differentiation or fit the student’s cognitive abilities. Through understanding concept of BICS and CALP I was able to distinguish between allowing students to use language socially and academically and determine student’s true level of comprehension within my science classroom. Lastly, with Bruner’s scaffolding these other two concepts are pulled together and given a structure to help give students a strong base to build upon as the unit progressed.

Researcher Background

I am a high school science teacher in my third year of teaching. I have taught at both the middle school level and high school level. My areas of expertise are in geosciences, physical science, and life science/biology. Prior to being a teacher I working with the CalTeach program at the University of California Santa Cruz, where I participated in classroom observations and student teaching. This program and my undergraduate minor in education started me on my journey to addressing my research questions. Through my early observations and reading on science education I learned that students were consistently able to explain content material in Basic English, but when asked to explain it using academic language student struggled. My first year of teaching was trial under fire as an intern as an eighth grade physical science teacher. My first year of teaching I continue to see this problem and started to addresses it in my lessons as an Earth science teacher at San Benito High School. My current position is teaching both biology and integrated science at the high school level. The main tribulations I have when looking at this is that we do not always know students individual prior knowledge of content; their ability to understand the expectations of the standards and learning objectives; and if it is the content vocabulary or the general academic vocabulary that they are struggling with.
Definition of Terms

**Pre-assessment:** An assessment of students’ knowledge prior to seeing the content before.

**Academic Language:** is the language needed by students to do the work in schools. It includes, for example, discipline-specific vocabulary, grammar and punctuation, and applications of rhetorical conventions and devices that are typical for a content area (Herr, 2006).

**Language proficiency:** is the ability of an individual to speak or perform in an acquired language.

**Second Language Acquisition:** Second language acquisition is the process by which people learn another language. (Gass & Selinker 2008, p. 7)

**SIOP Model:** is as researched based and validated instructional strategies that address the academic needs of ELL students through eight interconnected components (Echevarria et al., 2011).

**Strategies:** ways which we try to address teaching content to students differently.

**No Child Left Behind (NCLB):**

**Common Core State Standards (CCSS):**

**L1:** is a native speaker using their native

**L2:** is a person’s second language, in which multiple factors determine whether or not they can acquire native fluency or only native-like fluency setting them apart.

**Learning outcome:** what the student should know and realistically be able to do by the end of an assignment, activity, class, or course. (University of Toronto, n.d.)
Chapter 2: Literature Review

Over the last 50 years researchers have been examining second language acquisition (SLA) and the barriers associated with learning a new language. Within education, barriers specific to SLA within content area classrooms have been a strong focus and this review will analyze that research with special attention to the field of science and the strategies that can be used. My research questions are:

- How do students who were taught science using SIOP strategies perceive the usefulness of those strategies for helping them learn to:
  - understand and use scientific academic language; and
  - master the science content in the unit?

- How has my teaching been affected as I implement the SIOP model into my classroom lessons and planning?

These questions reach back as far as Cummins (1979, 1981a, 2007), who began with examining how students’ ability to speak English had nothing to do with how much content they truly understood setting in motion a new research agenda for education and other related fields. In middle school and secondary science classrooms today, students are expected to be able to read, write, and speak on an academic level, but how can we overcome the barriers that English language learners (ELLs) face when we do not know how to properly achieve these skills yet?

This review will address three main ideas in regards to how the SIOP model and strategies will help students gain second language acquisition. First, what are the current barriers students are faced with in the classroom as a whole and how do we remove them? This will examine what
is hard overall for students as they obtain second language and what skills are required for them to gain that knowledge. Second, how can the SIOP model help students obtain second language acquisition? Third, what is the importance of increasing SLA in the science classroom?

**Barrier to Second Language Acquisition (SLA)**

I will be examining the barriers of second language acquisitions (SLA) age, difference in learning outcome and by external factors that influence SLA. Within each of these subareas I will examine how our understanding of them has changed over time and how each one influences the others. The examination of barriers to learning have been examined for decades, while SLA has only begun being examined in the last 60-50 years. Some of the first to examine this area of study were psychologist; such as, Vygotsky who examined how children learned, but not in different languages just in their native languages. (Vygotsky, 1979; Cummins, 1980, 2008; Collier, 1987)

**Age.** The age that students begin to work on a second language, be it academically or requirement, plays a huge role in how students process that language and acquire a full understanding of it. Since language acquisition begun being studied we have looked to students to model this process and difficulties. Collier and Loschky both have examined this barrier and its associated barrier of obtain proficiency in the acquired language. They explain that students who begin earlier in their lives were able to acquire language and be proficient at grade level faster than those that enters in the middle and high school levels. (Collier, 1987; Hulstijn, 2007)

Collier came to the conclusion that student “Arrivals at ages 12-15 cannot afford to loss time in academic instruction…it may take theses advantaged LEP students anywhere from 4-8 years or more to reach the 50th NCE on standardized tests across all the subject areas.” (1987, pg. 637)

This conclusion shows that at the secondary level English language learners need to highly
supported and given as much academic instruction as possible to help them achieve at a proficient level by the time they leave the 12th grade.

**Differences in learning outcomes.** From looking at age we can already see a difference in students across the academic board when it comes to SLA. We can further see that learning outcomes play a role just as strongly as the students’ age of starting to acquire their new language. Cummins and Saville-Troike both studied this phenomenon. The conclusions from both were that students had different language needs for social and academic speaking skills. Cummins coined the terms BICS, basic interpersonal communicative skills, and CALP, cognitive academic language proficiency, in 1979. We still use these terms today because this barrier is never ending.

We have as educators tried to help students with these needs as Saville-Troike discusses in her conclusion to “*What really matters in second language learning for academic achievement?*” This barrier is seen when students can speak the second language well enough to communicate with peers and respond to basic questions asking in the classroom, but cannot utilize the second language in an academic setting. Over three decades later Cummins (2008), returns to his BICS and CALP distinctions and reminds us, “The BICS/CALP distinction was not proposed as an overall theory of language proficiency but as a very specific conceptual distinction that has implications in policy and practice” (79) Just the way that Saville-Troike suggest that we find practices to help students distinguish between these, not to just allow them to socialize to help them learn, that it goes beyond students just talking.

**External factors.** As we examine second language acquisition in English language learners we can tell that there aren’t just a few crucial factors that play a role in how they actually acquire
the new language. Many of these studies showed that they needed further research and that other areas were coming into play that were not anticipated. Both Collier and Cummins examined students to see how social interaction played a role in SLA, coming to the conclusion that social interaction helps on some level but that students need further instruction in how to use this in the academic setting. Even beyond the simplification of any language is all language assumed before the BICS/CALP designation there was still the fact that course work get more rigorous as students’ progress from grade to grade and if their SLA and proficiencies is still behind then the combined pressure of a more rigorous schedule and expectations can cause ELL students to struggle even more. (Collier, 1987; Cummins, 2008; Loschky, 1994)

Additionally, we as teachers bring in our own preconceptions. We have gained them through our teacher training programs, personal pedagogies, and literature we have read. Hulstijn, Nassaji and Shanahan and Shanahan both discuss these topics in depth. Our teaching programs instill in us a set a strategies and expectations that cause us as teacher to later have a hard time integrating new techniques, or limit us because we have not had enough professional development to increase our abilities in the ever changing field we work in. As I previously stated, our classroom dynamics are changing as we increase our ELL student percentages each year, but how many teachers are truly prepared for this? Most are learning as we go, as was shown in Nassaji’s study the relationship between SLA research and our language pedagogies when he found most could access the current research but were not reading it or applying it, but instead utilized their own techniques with students( Nassaji, 2012). This is reiterated by Hulstijn as a major fundamental issue in the area of SLA research because it is not being utilized by teachers, nor are all the players who are looking at SLA from different fields, such as; neuroscientist studying language, linguist, and cognitive psychologist( Hulstijn,2007). This fact that so many fields are studying
the topic of SLA means that we should be closer to understanding the process and how to help students learn, but because that lack of integration between all of these fields we are lacking insight still.

In addition, students have their own external factors; such as, the quality of their second language exposure, the amount of the second language they are exposed to socially and academically, and even their personal aptitude towards the language. These external factors can cause students to achieve higher, lower or not all over the course of their SLA journey (Collier, 1987; Cummins, 2008; Hulstijn, 2007; Saville-Troike, 1984). Many of the students today obtaining SLA are around only their native language for social gatherings and home life. This means that they are only practicing its use during school hours, which limits their time and exposure. Some students are also in English language development courses which mean instead of being exposed to students who are highly functioning in the second language, they might only have a teacher using the language properly and again could become limited in their own SLA because of this.

How we can address the barriers of SLA

Researcher have been continually discussing the components of Second Language Acquisition (SLA) that they feel should be put in place to help remove these SLA barriers. This focus highlights Cummins’ original hypothesis that the more students who only have Basic Interactive communication skills interacted with English only (EO) students the more language they learn overall, yet we are still struggling to understand these barriers.

Teacher training and research. A major barrier to SLA is the lack of collaboration between the different areas that are studying SLA. The majority of pre-service teachers receive minimal training in second language techniques and the research that helps support these
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students. Even when they are trained through professional development teachers feel that their personal experiences support their understanding of how to help English Language Learners is better than the research that they have been exposed to (Hulstijn, 2007; Nassaji, 2012). This perceived divide is not allow new teachers and current teachers the ability to access new information that they feel is relevant or useful.

Though researchers in linguistics, SLA, and psychology are the ones that are determining how students who are obtaining SLA and how that works, teachers are the ones that on daily bases are working to help those students to achieve. A more collaborative practice were these fields work together could create the opportunity to disintegrate the divide between research and practical application in the classroom. This would remove the different goals that surface from research and teaching since they are on different sides of the spectrum in learning about SLA. Beyond this even is the bias about SLA that teachers bring to the classrooms as they are teaching and how those bias push them from utilizing with fidelity SLA strategies and models, thus a collaboration between fields could create less bias and an more open view of SLA teaching strategies. (Hulstijn, 2007; Nassaji, 2012, Shanahan and Shanahan 2008; Tan 2011)

Support with new English language Learner Students for SLA. Multiple times over the last 50 years of SLA research it has been noted that students who obtaining a new language, or any language, need to be exposed to that language as much as possible, even when they are very young. SLA is a complex process that can take many years to bring a child up to par with the standardized test expectations. In school aged children this process can take up to 5 years, while students who start to obtain the new language during secondary schooling, middle school to high school, can take up to 8 years to fully acquire the knowledge they would need to be proficient in all content areas (Collier, 1985; Shanahan and Shanahan, 2008).
Increased use of Academic English in the classroom. Since the 1980’s researchers have been focused on addressing the amount of academic language used within English and content area classrooms alike. They have expressed that English Language Learners who are placed in either bilingual or main stream classrooms were gaining in language socially, but not able to apply it to academics (Collier, 1987, Cummins, 1980A; Cummins, 2008). Shanahan and Shanahan (2007) discuss this factor and suggest creating content specific literacy strategies and routines to help these students meet the more rigorous demands of secondary and middle school classrooms. Others have also addressed this by suggesting highly intensive vocabulary strategies and creating cognitively appropriate scaffolding of content specific vocabulary while integrating academic language (Saville-Troike, 1984; Taboada and Rutherford, 2011; Shanahan and Shanahan, 2008).

The SIOP Interventions for SLA

One of the suggested strategies that has been studied by new teachers and researchers alike, is the Sheltered Instruction Observation Protocol (SIOP) model teach strategies. The SIOP model of teaching is, “an approach for integrating language development with content teaching, provides teachers with guidance for planning and delivering effective lessons” (Echevarria and Short, 2011). Through the use of the SIOP model strategies, all students are exposed to a higher level of language acquisition through content literacy, while teachers have the flexible teaching strategies and lesson flow to not feel unnatural teaching using this method. Several study’s have been done over the years on if the use of the SIOP model is an affective achievement driver for all language designations, and have shown that it does increase students’ scores; while others have pointed out that the use of SIOP in ELL courses is not effective due to lack of strong native
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speakers of the (Echevarria, Richards-Tutor, and Short, 2011; Echevarria and Deborah Short, 2011).

**Positives.** All studied where student achievement has been measured through intervention with the SIOP model has shown that it does increase student comprehension and abilities. Students who were taught consistently using SIOP strategy were seen to have a higher level of performance on assessment than those groups who did not receive the intervention (Echevarria, 2005; Echevarria, Richards-Tutor, and Short, 2011; Echevarria and Deborah Short, 2011).

**Negatives.** Though the SIOP model has proven to enhance student achievement, there are negatives to its use that have to be countered with in content specific classrooms, such as science. Short et al. (2011) and Echevarria et al. (2011) expressed that the teachers’ commitment and professional development played a large role in students having a negative or positive increase from the use of SIOP model strategies. Teacher pedagogy plays a huge role in the effectiveness because if a teacher is unwilling to use the strategies every day, it is not as effective for students. Another negative is the fact that SIOP strategies limit content specific teachers, such as science teachers, from the use of inquiry teaching methods (Settlage, Madsen, and Kerri, 2005). Lastly, the term Sheltered has a metacognitive connection to others that ELL students are not capable of the work, need protections. Thus, creating sheltered classrooms with diverse expectations from one another and student mindsets that are changing class to class (Fritzen, 2011).

**Importance of removing SLA barriers from science**

With all these barriers affecting English language Learners (ELL) across all spectrums, how do we remove them in science and why is this important to do? The overall conclusion is
that academic language and content specific vocabulary play a large role in creating access to content knowledge.

**Content language Skills.** “Science for all, including students from non-English language backgrounds”, was published in 1998 and was piece research that took into consideration what it was like to use, learn and comprehend content information for students. Moving forwards from this with the NCLB push for testing all student's and the need for all students to achieve higher; researchers started to look at what this idea would mean to science content courses. Many researchers find that content language skills are just as important as the academic language that surrounds it, because if you do not know the content vocabulary, you do not understand the concepts fully (Lee and Fradd, 1998; Taboada and Rutherford, 2011; Tan, 2011).

**Academic Language.** This idea is imperative to academic language as well as the science content information. Scientific language is just that, another language unto itself. Shanahan and Shanahan (2008) discussed how literacy within the content areas requires teachers to not just teach the content, but to also clarify the meaning of academic language that students are unfamiliar with within science and other content areas. In the creation of the SIOP model strategies Echevarria and her co-authors allowed for this by creating a scaffolding process that help students to reach the content and the academic language used in the classroom. This practice goes back to Bruner, Krashen and Cummins, who explained that social interaction, such as what students hear in a classroom, is what leads to SLA and language learning in general (Short et al., 2011; Cummins 2008; Tan, 2005; Madsen, Rustard, and Settlage, 2005; Shannon and Shannon, 2008; Taboada, 2011; Echevarria et al., 2011, Jerome Bruner 1985)

**Conclusion**
In conclusion, there are multiple barriers to second language acquisition in the science classroom that have to be overcome by ELL students. Cummins's research over the last few decades has been used as a baseline for understanding how ELL students function in this environment. Today, we no longer use the terms BICS or CALP as strongly, as in the past. Instead we focus on the terms general vocabulary and academic vocabulary. Yet, we are still analyzing this topic to find the best way to address these barriers. One of the most strongly supported strategies is the SIOP model. Though it has many strengths, it still has areas that need to improve. It is important to overcome these barriers for students, because without being able to access information properly or be taught in a manner that allows them to learn, they will not be able to achieve their full academic potential. Thus, it is significant that these barriers are removed and that researchers and teachers come together to create strategies that are affective and natural fits for the science content classroom.
Chapter 3: Methods

In this section I will describe the methods I am using to gather and analyze data to answer the research questions I proposed, including the following:

- How do the perceptions of students who were taught science using SIOP strategies compare to those of students taught science using traditional methods, with respect to how well they think they were able to:
  - Understand and use scientific academic language; and
  - Master the science content in the unit

- How has my teaching been affected as I implement the SIOP model into my classroom lessons and planning?

Overall Research design

I am using action research because this method is used to allow teachers to improve the practices in their classrooms and to improve students learning outcomes. The type of action research I am using is practical classroom action research (CAR). I choose to use the CAR design because it is designed to allow teachers to choose a specific problem within their classrooms that they wish to improve upon by choosing an assessment or curriculum intervention to implement in their classroom with the drive to see improvements for students.

CAR provides the opportunity to collect rich sources of data to create an effective way to modify and improve a student’s chances for success (Hendricks, 2006). In CAR you utilize every kind of data source that allows for relevant information to the problem to be addressed, including both qualitative and quantitative data; both will be used in this study. Though not typical for action research, I am using a comparison group in my study to allow me to see how students’
achievement differ between the two studies and how that correlates with students personal
perceptions of their understanding.

Procedures in detail

The setting of my study is Environmental High School, in Central California. The following
information is taken from the city and school websites.

“Coastal City” is fairly moderate sized city. According to the U.S. Census (2012), it has
a population of approximately 51,881 people. In 2010 the population was approximately 13.7%
White alone, 14% Hispanic or Latino, 0.7% African American, 1.2% American Indian and
Alaskan Native, 3.3% Asian, 0.1% Native Hawaiian and other Pacific Islander, and 4.4% Two
races or more. In the United States, California has the largest number of immigrants compared to
any other state (Johnson and Cuellar Mejia, 2013). For “Coastal City” Approximately 18.6% of
families and 20.4% of the population were below the poverty line, including 27.6% of those
under age 18 and 15.6% of those age 65 or over. Therefore, although the median household
income did rise significantly between 2000-2010 (unadjusted for inflation), the percentage of
city residents experiencing poverty rose at a faster rate.

Coastal City is home to approximately 560 documented gang members and 9-10 known
gangs. While gang activity is on the rise, crime itself continues to fall and is currently at its
lowest in 30 years. Despite a significant drop in crime, Coastal City continues to suffer from its
past reputation, particularly amongst more affluent areas in the region. Part of this is due to the
poverty levels in Coastal City being 29%, 10% high than the state of California, as of 2009. Of
that 29%, 9.2% of these residents are living at 50% below the poverty line. The majority of the
males living below the poverty line are between the ages of 0-14, females being in the majority
between these age ranges also. With the number of Hispanic or Latinos living in poverty is
9,534. Whites constitute 847, African Americans constitute 134, American Indian or Native Alaskan constitute 150, and people other or more than two races constitute 3,892 people living below the poverty line. The majority of the family types that are living below the poverty line constitute females with no husband present at 47%. The percentage of children below the poverty level overall is 27.3%.

Coastal city unified school district is a K-12 district that includes 34 schools. It includes two main stream high schools besides Environmental High School. It is the largest central coast district and the largest employer of Coastal City, with over 2000 employers (both certified and classified) as of the 2010 comprehensive annual financial report. Environmental High School has 56 regular single subject teachers ranging from English to ROP course work.

Environmental High School serves students who live in Coastal City, which has a largely agricultural-based economy and a large mobile population of farm laborers who maintain ties with Mexico. High poverty and overcrowding exceed that of other cities located within the county, and the surrounding area has one of the highest housing costs in the country with one of the lowest per capita incomes. Of our students 80% participate in the free/reduced lunch program, and 26% are children whose parents attended college (compared to 59% statewide). Many of our students’ parents do not speak English or have only limited English proficiency.

Environmental High School’s student population is 89% Hispanic, 2% Filipino, and 9% White or of mixed race. The percent of English language learners (ELLs) is 46% and continues to grow. The schools demographic is made up of 94% Hispanic/Latino, 2.74% White, 2% Asian, .68% Black, and .14% Native American/Native Alaskan. Gender ratio is 50/50 with
approximately 724 Female and 736 Male. Currently the largest classes are the freshman and sophomores at 28% and 29% of the population respectively.

**Participants**

The participants for my study were two classes of biology. The intervention group and the control group which had a similar demographic consisting mostly sophomore students with a few freshman students, one junior and one senior grade student.

The Control Group had 33 students: 27 sophomores, 4 Freshman and 1 Junior. Two students refused to participate in this study. There were 12 Males students who were Hispanic/Latino, 2 of whom receive special education services (SPED). There was 1 English Language Learner (ELL), 1 Bilingual student, 1 English only and 10 Reclassified students. They were a Freshman and 11 Sophomores students ranging in age from 14-16. This group had 19 Females. All were Hispanic/Latino. There was 1 SPED student, 5 ELL students, 3 English only students, and 10 Reclassified students. They were 4 freshman, 13 sophomores, and 1 Junior, ranging in age from 14-17.

The Intervention Group had 29 students. There were 24 sophomores, 4 freshman, 2 juniors, and 1 Senior. The Senior Male student was not included in the study due to his re-attempting the course and large age difference. Of the remaining students there were 15 Males. All were Hispanic/Latino, 2 of whom are SPED students. There were 3 English Language Learners, 1 Bilingual student, 3 English only, and 5 Reclassified students, 3 Freshman, 12 Sophomores, and 1 senior, ranging in age from 14-18. There were 15 Females. All were Hispanic/Latino. There were 2 SPED students, 6 ELL students, 1 English only student, and 6 Reclassified students. There was a freshman, 12 sophomores, and 2 juniors, and students ranged in age from 14-16.
Students. I choose six students, three from each class, selected based on their rubric scores at the end of the unit. I choose students who scored within the low, average and high sections of the rubric score range, from 0-28. This gave me an idea of how students from all levels perceived the teaching intervention and control method and their personal growth from the beginning to the end of the unit.

The students from the control group were:

- Sunny: a 14 year old freshman female student who scored a perfect score on the rubric.
- Hillary: a 15 year old sophomore female student who scored in the top of the middle range for the rubric.
- Steven: a 15 year old sophomore male student who scored in the middle of the low range for the rubric.

The students from the intervention course were:

- Angie: a 15 year old freshman student who scored a perfect score on the portfolio rubric.
- Bobby: a 16 year old sophomore male student who scored in the middle of the middle range of the rubric.
- Daniella: a 16 year old sophomore female student who scored at the low end of the portfolio rubric.

These students were given a written open-ended questionnaire and asked to use the weekend to respond to the questions in as much detail as possible. They returned it to me and I read through their responses and spoke with them after school individually to clarify any remarks I was unsure about.

Teachers. In CAR teachers are participants. This study will just involve me because it is examining my own teaching only. I am a female European-American with just over two years of
teaching experience, primarily in high school earth science. I have a bachelor's degree in earth science and anthropology with a minor in education from University of California: Santa Cruz. I completed my single subject credential at California State University Monterey Bay in geological science and life science/biology.

**Data collection procedures**

The intervention is comprised of a unit created using the sheltered instruction observation protocol (SIOP) model of teaching. The SIOP Model provides a systematic approach for making content accessible and for consistently focusing on academic language. (Echevarria, 2007). It has eight main steps: preparation, building background, comprehensible input, strategies, interaction, lesson delivery, practice & application, and review & assessment. Though SIOP is a sheltered instructional observation protocol model it shares many qualities with high level instruction such as; cooperative learning, reading comprehension strategies, differentiated instruction and an emphasis on the writing process. I will be utilizing the SIOP lesson plan format and utilize the SIOP rating instrument to help me develop the unit’s lessons and delivery methods. The unit will be focused on the National science standards for biology with a focus on academic language, science content literacy and content knowledge. The unit will take 4 weeks and the students will have two 110 minute course and one 42 minute course each week.

First I created several SIOP model unit lessons and classroom practices to create a tool box for the unit that students will be studying. Secondly, I chose my intervention class and control class. My block 3 class was my control group and my block 5 is my intervention class. This is because my block 5 students have a highly differentiated content knowledge background and the higher level of English Language learners. Students are not assigned randomly for this study due to previously set class schedules.
At the beginning of the unit all students were given the pre-unit questionnaire to complete. This questionnaire is to give me an understanding of where students believe they are before the intervention begins. Students completed the questionnaires in their own classroom by means of a Google form through my CSUMB Google drive account, using Chrome books and without help from peers. Students were given 35 minutes to complete the pre-unit questionnaire. The results were sent automatically to my Google drive in the form of a spreadsheet.

Next, the intervention class will be taught exclusively using the SIOP Model strategies and lessons over the course of 5 weeks, while the control group received only didactic and low level inquiry teaching methods, reflecting the traditional method of teaching in the classroom.

At the end of the unit all students turn in a completed unit portfolio made from the work of the unit. It was graded on a scale from 0-28 with each category able to obtain a maximum score of 4. The areas of examination for the rubric were the content area and academic language for the classwork, lab work and final project, along with the overall organization and neatness of the portfolio.

At the end of the unit Students completed the post-unit questionnaire at the end of the unit. Again, they completed the questionnaires in their own classroom by means of a Google form through my CSUMB Google drive account, using Chromebooks and without help from peers. As the post-unit questionnaire includes five additional items, students were given 45 minutes to complete it. The results will be sent automatically to my Google drive in the form of a spreadsheet.

From the control and intervention blocks I selected 6 students, 3 from each class that represent the top, middle, and bottom achievement levels from the unit portfolio and ask them to
elaborate on their questionnaire response to help understand better their perceptions of their comprehension based on the intervention or control group teaching method.

**Data collection and data sources**

In the assessment portion of this study, students completed a teacher made unit rubric worth a total of 28 points based on 6 categories. The portfolio’s contained work from the course of the 5 week unit. Students completed the pre and post unit questionnaire that I designed using google forms. The questionnaires were made of a Likert rating scale and open ended questionnaire related to my students’ unit that consisted of 10 questions on the pre-unit version and 15 questions on the post-unit version. Three questions were closed-ended and ask students to rate their knowledge based on a Likert-style scale ranging from 1 = no understanding to 5 = thorough understanding. The remaining questions were open-ended. All questions pertain to students’ prior content literacy, academic literacy and understanding of the content knowledge. For example, students will be given the following standard and were asked to pick where they rate themselves.

Ex. HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

| No understanding | 1 | 2 | 3 | 4 | 5 | thorough understanding |

Most of the items on the questionnaires were open-ended. These open-ended questions also pertain to students’ prior content literacy, academic literacy, and understanding of the content knowledge. For example, I asked students to explain what words they know, what concepts they remember and which words from the standards confuse them. Students were given up to 500
characters to express their understanding and personal feelings about the standards. Examples questions used were:

"The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?" and "The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?"

As mentioned, I selected six students to interview based on their post unit scores. Interviews consisted of questions that extrapolated the post-unit questionnaire responses. Students were give the questions before hand and asked to answer to the best of their ability and with as much detail as possible. Then I read through their responses and spoke with them one on one to clarify their answers. All data collection will be done by me.

Data Analysis

Students were assessed on their unit portfolio. The unit portfolios were analyzed by using bar graphs and comparison charts between the control group and intervention group. These simple visual graphs showed if there is any correlation between the teaching method being used and the students' abilities with content and academic vocabulary and content knowledge.

The student's questionnaire data from the rating scales was assessed using descriptive statics. I examined the data using the mean, mode, range and score frequencies for each of the six content information and academic language sections. These results were placed into simple bar graphs for the pre and post unit to show where students are placing themselves on their understanding before they obtained the knowledge and after. The open ended questions were
coded, and broken down first by codes determined by my research questions. These codes will be added to as they emerge throughout the coding process. After the questionnaire has been coded and all connected codes put together to create overarching themes. I applied my findings from the quantitative and qualitative data analysis to answer my research questions.

Limitations/Threats to Internal Validity:
Throughout the study efforts were made to keep the threats to internal validly to a minimum, action research has many potential threats to validly and usefulness of the findings obtained. I have been trained to utilize SIOP model strategies, but I am not an expert on this method and there is the possibilities that I will not implement it as adequately as it is designed to be. Having my unit only be four weeks long might be too short a time period to examine my research question, but the shorter period of time will limited the remaining threats to validity.

My intervention group and my control group share other courses and my intervention group might have begun to feel more privileged than the control group and thus worked harder; while the control group might have become resentful of the intervention group and may have stopped trying due to "resentful demoralization. I created my study unit and discuss it with Professor Carolina Serna who teaches sheltered instruction courses at California State University Monterey Bay and my New Teacher Program support mentor, Sheryl Pinard used the Shelter Instruction observation protocol rating instrument and the lesson plan and delivery system protocol to try and ensure that I implemented the SIOP model as fully as possible in my intervention course.

Lastly, experimenter bias is a major threat to validity in my study because I will be the only data collector/analyst. I will be using student identification numbers instead of student’s names for all questionnaires and the final unit portfolio so as not to have student bias during the grading
and coding process. I am choosing this identifier because students know it by heart but I do not know these numbers without intensely looking up their information.
Chapter 4: Results

The purpose of this study was to see if utilizing the SIOP model intervention would allow students to obtain a higher understanding the science content and increase their academic language skill. The researcher, myself, provided students in my third block didactic lessons and fifth block lessons based on the SIOP model strategies in hopes of seeing a higher level of comprehension in my intervention class compared to my control group class.

As discussed in my chapter three my study yielded both qualitative and quantitative data. Due to their vastly different ways of being analyzed I will be looking at each section of the study independently. I will look at the unit chronologically starting with the pre-unit questionnaire, then portfolio and lastly the post unit questionnaires and interviews.

Pre-Unit Questionnaire

The pre-unit questionnaire was made up of 20 questions (Appendix A). The majority of the question were open ended and pertaining to the next generation science standards (NGSS) that were used to create this unit. There were 12 questions based on the four focus standards from this unit. For each standard student were given a Likert scale from 1-5 to rate themselves on how well they thought they comprehended the standard. The remaining questions gave me students ID numbers, age, gender and which block they were associated with. The students were given 35 minutes to complete the google form questionnaires using Google Chromebooks and not allowed to discuss the questions with their peers or the instructor, me. Students who were absent that day had to make up the questionnaire in a tutorial block the next time I saw them.

From this Unit there were 82 responses submitted by my students (Appendix A). Ten of these responses were students that had submitted without responding, and they went back and re-submitted their responses. There were also 6 responses from students who left the classes after
the beginning of the unit and 4 responses that were completely blank. From the 63 responses from students that I examined I created several themes for each question. Due to the nature of the questions I was able to examine the questions based on what they were asking students to examine. The questionnaire focused on creating a base line of students understanding of the unit’s scientific academic language and prior knowledge.

**Qualitative analysis**

The data analysis of the questionnaire yielded that: 1) Students had a acted like they knew what the standard meant 2) students admitted they had no idea what the standard meant 3) Students tried to link the standard to the previous units, 4) that students felt that both academic language and science content troubled them in biology.

*Students had a acted like they knew what the standard meant*

A common theme throughout the questionnaire was students re-stating the standard from the question added vague information. The fact that students are restating the information means that they understand that they have to know the standard, and many who did this choose to repeat only a section of the standard that they understood or found to be the most important. Though this is similar to the next theme it stands on its own due to the high frequency and the fact that is shows students have created a mechanism for when they do not understand something fully they will just repeat it back in a slightly changed format, such as changing from a question to statement.

*Students admitted they had no idea what the standard.* A common theme throughout the questionnaire was students stating, in multiple forms, that they did not understand the Next Generation Science Standards. Out of the 63 questionnaires examined over 50% students wrote
in some fashion that they did not understand the standard. This was expected because this was a new unit.

**Students tried to link the standard to the previous units.** Fewer students fell into this theme but it is important to note that students were trying to connect prior knowledge to a topic they felt uncomfortable with or had never seen. These students, though creating mostly incorrect connections, showed me that there was an area of misconceptions that would need to be addressed by this unit.

**Students felt that both academic language and science content troubled them in biology.** Overall, students expressed equally that science content and academic language both were confusing. Each standard showed a difference in percentages but, overall between both groups for all four standards it I saw a 50/50% for science content information and academic language being the hardest part of the new NGSS standards for my students.

**Quantitative.** Students were asked which part of the standard they felt was the most difficult to understand from the standard, the science content or the academic language, to allow me to see where students felt they were weakest starting the unit. This is to help gage how far students have improved in the area of content information and/or academic language. For standard 1.4 my control group had 70% say academic language was the hardest part of the standard, while only 30% said it was the science content. In comparison, the intervention class had 37% of students say academic language, 63% say science content information and 0% have no response. My control group had 43% of the students say science content was the hardest part of standard 3.1, while 54% said the academic language was the hardest part for them. While the intervention class had 40% of students say academic language, 54% science content information and 6% did not respond. For standard 3.2 the control group had 61% say academic language
while 33% said science content information and 6% did not respond. The intervention class had only 29% of students say academic language, and 60% say science content. This was the largest intervention class no response section with 11% of students not putting either option. Standard 3.3 had the control group saying 58% of them thought that academic language was the hardest, while 27% said the science content information and 15% of students did not respond at all. The intervention group for standard 3.3 had 31% say academic language was a problem, 63% say science content and 6% with no response.

Lastly, students answered a Likert scale question pertaining to how well they felt they understood the four standards. Students' could choose from one to five, with one being they highly agreed that they understood and a five being that they had no idea what it was saying at all. Overall for both groups the majority of the students choose the neutral three option (Appendix B). The control group had a higher number of students choose two's and fives. The relationship with the intervention group is that they had a higher number of students choose the one option saying that they comprehended the standard at the beginning of the unit. Neither group choose the five option, which would have been indicated by their answered to the previous questions where approximately 50% of students choose to say they did not understand the standard.

**Portfolio**

Overall for this unit students had to create and complete a unit portfolio. This portfolio consisted of the students’ notes, classwork, homework, labs, and final project source information. Students were supplied with a 3 bracket folder in their classes designated color where they had to keep a table of contents up to date and keep all work. This portfolio was worth 28 points overall and was graded using a teacher made rubric. The rubric covered the following
areas: organization; content information for classwork/notes, labs and project; and academic language for classwork/notes, labs and project. Students could achieve between zero and four points per each of these 7 sections shown in Table 1. My areas of focus were the content information and academic language sections for classwork, labs and the final project.

Table 1.

**Genetics Portfolio Rubric**

<table>
<thead>
<tr>
<th>Points</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization/Neatness</strong></td>
<td>Was unorganized, had not order to the information submitted, did not use table of contents page, work was not readable</td>
<td>Work was mostly unorganized, had a strange order, tried to use table of contents, work was semi-readable</td>
<td>Work was slightly organized, had an order that was detectable, tried to use table of contents and work was mostly readable</td>
<td>Work was organized, had an order that was defined, mostly used the table of contents correctly, and work was readable</td>
<td>Work was organized, had a set order that was very clear, used the table of contents correctly, and work was readable</td>
</tr>
<tr>
<td><strong>Content Information Class work</strong></td>
<td>Student did not use any of the content information for their class work or it was missing all together</td>
<td>Students had 30-60% class work included and what there had the incorrect content information</td>
<td>Student had 61-75% of the class work included and had about 65-79% of the content information correct</td>
<td>Student had 76-89% of the class work included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the class work and it was 90-100% correct</td>
</tr>
<tr>
<td><strong>Content Information Labs</strong></td>
<td>Student did not include Labs or what was included was under 30% correct for the content information</td>
<td>Student had 30-60% of the labs included and the majority of the content information was correct</td>
<td>Student had 61-75% of the labs included and had about 65-79% of the content information correct</td>
<td>Student had 76-89% of the labs included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the labs and it was 90-100% of the content information was correct</td>
</tr>
<tr>
<td><strong>Academic Language Class work</strong></td>
<td>Student did not include class work or what was included was had less than 30% of the required academic language (10 words per assignment) or all words were miss used</td>
<td>Student had 30-60% of the academic language included and had 31-64% of the required academic language used correctly</td>
<td>Student had 61-75% of the academic language included and had about 65-79% correct</td>
<td>Student had 76-89% of the academic language included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the academic language and 90-100% of the academic language was used correctly</td>
</tr>
<tr>
<td><strong>Academic Language Labs</strong></td>
<td>Student did not include Labs or what was included was under 30% correct for the content information</td>
<td>Student had 30-60% of the labs included and the majority of the content information was incorrect</td>
<td>Student had 61-75% of the labs included and had about 65-79% correct</td>
<td>Student had 76-89% of the labs included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the labs and it was 90-100% of the content information was correct</td>
</tr>
<tr>
<td><strong>Final Unit Project Content Information</strong></td>
<td>Student did not use any of the content information for their final project or it was missing all together</td>
<td>Students had 30-60% of the final project included and what was there had the incorrect content information</td>
<td>Student had 61-75% of the final project included and had about 65-79% of the content information correct</td>
<td>Student had 76-89% of the final project included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the final project and it was 90-100% correct</td>
</tr>
<tr>
<td><strong>Final Unit Project Academic language</strong></td>
<td>Student did not include the final project or what was included was had less than 30% of the required academic language (10 words per assignment) or all words were miss used</td>
<td>Student had 30-60% of the academic language included and had 31-64% of the required academic language used correctly</td>
<td>Student had 61-75% of the academic language included and had about 65-79% of the required language used correctly</td>
<td>Student had 76-89% of the academic language included and had about 80-89% of the required language used correctly</td>
<td>Student had 90-100% of the academic language and 90-100% of the academic language was used correctly</td>
</tr>
</tbody>
</table>

Total Points /28
Overall Portfolio scores

The class average for the portfolio’s showed that there was only a 0.18% difference between the control group and the intervention group’s scores. Looking at Table 2 you can see that the control group had a larger number of portfolio’s that scored in the A range which caused the two class average to be similar. Both classes had approximately 20% of students receive a non-passing score on the portfolio. While the intervention class had a larger percentage of students score an average grade of 75%. The control group had 29% score a C while the intervention group had 34% score a C grade. The Intervention class had 17% of students score an A (90-100%) while the control group had 26% of students score an A. The control group had a smaller percentage of B scores with 26 % and the intervention class had 28%. The standard deviation of the control group was 8.77 point difference, while the standard deviation for the intervention course was 6.53 point difference. The fact that the standard deviation is smaller in the intervention course shows that though they had an average grade similar to the control group there was less of a spread between the scores.

Table 2

<table>
<thead>
<tr>
<th>Portfolio Grades</th>
<th>Number of Control Students</th>
<th>Number of Intervention Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-F (0-1)</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>C(2)</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>B(3)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>A(4)</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>total</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Class Average Percentage</td>
<td>68.72%</td>
<td>68.90%</td>
</tr>
</tbody>
</table>
SIOP Strategies in the Science Classroom

The individual scores for each section are more informative. When looking at the content information sections from the rubric (Table 1) you are able to see this difference better.

There were three sections that looked at students’ content information understanding: classwork, labs, and the final project. Students were able to get from a zero, know turning it in or having less than 30% of work done, to four points, which was the exceeds the expectations and students have 90-100% of the work done correctly. In this section there was a very obvious shift in students’ ability to obtain mastery.

**Content information.** By looking at Table 3 you can see the three areas and where students fell on the 0-4 range for the three sections measuring students’ content information abilities.

Table 3

![Content information: Classwork](image)

![Content information: Project](image)

![Content Information: Labs](image)
For the science content information students from the control group scored similarly in comparison to the intervention course. The class sizes are slightly skewed with the control group having a larger number than the intervention due to changes in the number of students. The intervention class scored higher overall in the area of classwork and the final project. While lab work was also a strength in the intervention class, there was a higher number of students from the intervention course that scored lower in that section as well.

**Academic Language.** The same shift that was seen with the science content was seen in an even stronger trend with the academic language uses associated with the portfolio. Just like with the science content there were three sections that I examined from each portfolio: classwork, labs, and the final project. Students could score from a 0-4 depending on how they were able to use academic language and how often it occurred in their portfolios.

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
</table>

**Academic Language: Classwork**

<table>
<thead>
<tr>
<th>Number of Control students</th>
<th>Number of Intervention Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

**Academic Language: Labs**

<table>
<thead>
<tr>
<th>Number of Control students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

**Academic Language: Project**

<table>
<thead>
<tr>
<th>Number of Control students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>
As you examine the graphs you can see that the control group had a normal distribution of scores for its students. The majority of them scored at the mean or within a standard deviation of the mean. Only 55% of students earned a 3 or higher on the final project, 35% on the labs, and 32% on the classwork. In comparison, the intervention class was shift towards the high end of the scores with almost 80% of students earning a 3 or higher on classwork, labs and the final project.

**Post Unit Questionnaire**

The post unit questionnaire was made up of 25 questions (Appendix D). The majority of the question were open ended and pertaining to the next generation science standards (NGSS) that were used in the unit. There were 12 questions based on the four focus standards from this unit. For each standard students were given two Likert scale questions where they were to rate themselves from 1-5 to rate on how well they thought they comprehended the standard and how they felt their comprehension changed. The remaining questions gave me students ID numbers, age, gender and which block they were associated with. The students were given 45 minutes in class to complete the google form questionnaires using Google Chromebooks and not allowed to discuss the questions with their peers or the instructor, me. Students were able to access the questionnaire for several days because they were in the process of also finishing their final project presentations. Due to this, many students did not take the questionnaire till after spring break, two weeks later.

From this Unit there were 56 responses submitted by my students. My pre-unit questionnaire had had 63 useable responses, meaning that only 89% of students from the pre-questionnaire were about to answer the post. From these 56 responses from students that I examined I created
several themes for each individual question. Due to the nature of the questions I was able to observe the questions based on what they were asking students to examine. The post questionnaires focus was to show the shift in student thinking from the base line created with the pre-unit portfolio and see how their felt their understanding had changed over the course of the genetics unit.

Examining both the control group and the intervention group there was a huge shift in student understanding. The major themes seen here were: 1) Full ability to explain the standard. And 2) Students still not understanding the unit. For each of these themes each standard looked slightly different.

For the Next Generation Science Standard (NGSS) Life science 1.4 students had to be able to “Use a model to illustrate the role of cellular division in producing and maintaining complex organisms.” and explain, “What does this standard mean to you?” (Appendix D). The control group had about 75% of the entire class explain part or all of the standard and show that they understood the key points of the standard. One of the best examples was, “Use something that can represent how cellular division produces an maintains complex organisms To draw the cycle of a cellular division in making and keeping the complex organisms.”(Appendix E) The reason I included this is because it shows that students understood that they needed to both represent cell division and know that it is the reason for complex life. In comparison, the intervention class had about 80% of students express partial to full understanding of this standard. The intervention class had a great explanation also, which articulated, “This means to me that cells need to divide to maintain complex organisms alive and to help them evolve” (Appendix E). This student exceeded the standard and connected the idea of cell division to
evolution, which was our prior unit. The pieces that students did not understand from both
groups was the way the standard was worded and how it maintained complex organisms.

The next standard was NGSS 3.1 which says “Ask questions to clarify relationships about the
role of DNA and chromosomes in coding the instructions for characteristic traits passed from
parents to offspring” (Appendix D). From this standard about 70% of the control group was
about to explain at least one of the key points from this standard, while approximately 30% said
they still did not know what this standard was saying. The intervention class had about 90% of
students explain the key points from this standard, and 10% say they did not understand this
standard still. This standard was hard for students to understand because of the use of academic
language used with the content vocabulary. This was evident when repeatedly students stated
what they did not understand by citing the standard its self.

NGSS 3.2 was the next standard and it expresses, “Make and defend a claim based on
evidence that inheritable genetic variations may result from: (1) new genetic combinations
through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by
environmental factors.” (Appendix D) This standard was confusing for 70% of the students in the
control group and the other 30% only partially were able to explain what it meant. Students in
the control group expressed that they did not understand the three ways that variations could
happen. A few students from each group explained that they needed more time to focus on this
standard. The intervention group had about 65% of the students understanding part or all of the
standard while 35% of students were still unsure or had forgotten what this standard meant. The
intervention group expressed that the area they were all still confused by was the environmental
factors. This was an area that I did not stress in the lectures, and expected to see a lower
understanding in because I had not covered it as in depth as the other ways variations occur.
The last standard covered was NGSS 3.3. This standard says, “Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.” This standard applied to student’s ability to do Punnett squares, which was the main focus of the second half of genetics unit. The control group had about 60% of the students express that they still did not understand this standard or needed more time to fully understand it, while the other 40% had the ability to explain part of the standard. The intervention group was much different, 70% of the students were able to explain the standards meaning using either basic language, science vocabulary, or academic language. The other 30% of the intervention either said that they did not know the standard, expressed it incorrectly.

The added question at the end of the post unit questionnaire asked students to look back at the intervention unit and tell me what they felt were their perceived strengths and weaknesses and why they stood out. This section showed me at over 50% of the control group felt weak overall for this unit and that they needed more time to focus on at least on standard. An example of a student’s comment on feeling weak in this unit was, “Some weaknesses are that I did not get as much practice with the subjects as I would’ve liked to have.” (Appendix E). In the intervention class these two themes were also present, but they also express that they felt the notes, though hard, were a strength throughout the unit. A student from the intervention course expressed this by stating, “My strengths are the note taking and comprehension of this unit because I can explain a lot of the information.” (Appendix E)

**Post Unit Interviews**

From the post unit interviews with the six chosen students I found 3 major themes. The first obvious theme was said by all students that this was a very hard and rigorous unit because of the science content and academic language combination. The second theme was that the Cornell
closed notes were a great tool no matter if it was done in the intervention class or the control group. Lastly, students suggested that I could utilize media more for notes because they felt the documentaries helped them hear and see the new science content and academic language.

**Rigorous unit.** When I created this unit I wanted to push my students from their comfort zone while trying to create new opportunities for them to learn the science content and a more rigorous use of academic language. All six of the students I interviewed mentions or clarified that they felt the unit was harder than normal and they felt that they needed to have more time within the unit to be able to use the science content and academic language at a “better” level. Sunny mentioned this multiple times as I walked through the clarifications with her. She was the high scoring student from the control group and this was an expected comment. Steven also mentioned that he wished he could have more time but only when asked to clarify his response to what he felt was a strength and what was a weakness. Hillary touched on needing time in her responses but when we clarified it was about needing to be in class more, because she had missed a lesson due to being out for another class’s fieldtrip during a vital set of notes that she never came in to get.

The Intervention students also discussed needing more time. Daniella, Bobby, and Angie expressed that they needed more time for this unit. Each of these students needed it in different areas of the unit though. If you refer to Bobby’s interview in Appendix G, he had expressed a need for more notes and time to synthesis them, so that he could explain the information better in his own words. Bobby represented the middle scoring students in the class, so this shows that those students felt that more direct instruction was needed. Daniella stated that she had not learned anything, and needed to go over the whole unit again. If you refer to her interview in Appendix G, you can see that her responses to the interview questions were limited and
clarifications added very little to her interview. She represents the lowest scoring students in the class and from looking at her portfolio score of a 12 out 28 it is obvious that she either did not participate, understand, and/or was not in class or thus unit, and it makes sense that she feels this way about the unit.

**Cornell Closed Notes.** As I read through the interviews for both the intervention class and the control group I noticed that almost all the students’ mentions how they used the notes and that they were useful to them. The style of notes that were used was Cornell Notes, but with a modification of inputting closed notes into the Cornell format. If you look at the example in Appendix H you can see that students are given the opportunity to both write and listen using this style and are required to go back and create questions or pin point key information for each section. These notes were mentioned by Steven, Bobby, Angie, Hillary and Sunny. Daniella did not mention the notes at, even when I asked her about them in our clarification session.

The three students from the control group discussed the fact that the notes helped them understand the material, and if they weren’t sure how to do the practice problems or a concept they could refer back to the notes before asking for help. The two intervention students also reiterated this fact and even expressed that the way the notes were given helped also because they could go back and used the same process we had used in our check in’s to verify their answers. Though these notes are not a didactic practice, they are the normal style for my classroom and the removal would have given students an idea of which course was the intervention versus the control. Thus, both sets of classes received the note packets. How they were modified for each group was that the control groups did not get formal check in’s, nor were they given the time to synthesis the information for their summaries and questions in class,
instead that became their homework. Whereas, the intervention course was given this time and had formal check in’s throughout the lectures and during the practice with the lecture materials.

**Use of Media for creating transfer.** My students have always liked the use of media, such as: video clips, podcast and documentaries. In this study I choose to utilize media less than normal, and my students picked up on this. From Sunny, Hillary, and Angie’s interviews I learned that they liked the choices of media that there offered in this unit, but wished to have had more. All three female students are reclassified English Language Learner students, who have been fluent for more than 3 years. The reasons for them liking the media options is because with the video clips and documentaries they feel that they can see and understand the concepts at a higher level of comprehension. Hillary expressed that the use of media allowed her to connect the content to real life situations, which helps her be able to explain it to others and herself. I was not expecting this theme to be seen in 50% of the interviews and when I clarified with the other three students’ two more also discussed with me how the documentary we watched helped them to visualize the process of meiosis and understand the connections from DNA and chromosomes to creating more complex organisms.

**Conclusion**

The intervention group did show a significant improvement of understanding of the science content and the academic language over the course of the five week unit. Their perceived growth was minimal for both groups. It appears that though the intervention did improve the students’ knowledge and there is significant growth in the area of science content and academic language for the intervention group, they did not perceive these differences when looking at the NGSS standards for the second time.
Chapter 5: Discussion

This study hypothesized that by using the SIOP model strategies in the science classroom students would perceive that the intervention strategies allowed them to better understand the science content and the academic language associated with the unit Next Generation Science Standards. The specific questions that were asked in this action research study were:

Within the context of my action research project I propose the following questions:

- How do students who were taught science using SIOP strategies perceive the usefulness of those strategies for helping them learn to:
  - Understand and use scientific academic language; and
  - Master the science content in the unit?

- How has my teaching been affected as I implement the SIOP model into my classroom lessons and planning?

These guiding questions allowed me to compare my students’ achievement in the science content and academic language of a genetics unit, and see how they perceive the NGSS standards used. Students completed a pre-unit questionnaire at the beginning of the five week unit, created a unit long portfolio of classwork, labs, and a final project, and completed a post unit questionnaire almost identical to the pre-unit questionnaire.

From the research and what my data showed, it is obvious that the SIOP model has the ability to help science students, no matter their language designation, achieve at a higher rate. The results from the portfolios and questionnaires shows that the students who received the
intervention did improve their academic language, while students from the control group stayed on a normalized bell curve. Scores for the academic language section of the portfolio showed that the control group really struggled with this section of the unit, while the intervention class had 80% of students achieve a score of three or four.

By having the pre-questionnaire the intervention students gave a baseline that the students did not know these standards, and that they felt both the academic language and the science content were both adding to their lack of comprehension. Though overall the questionnaires showed that the students from the intervention felt like the strategies did improve slightly, but not enough for it be a significant change in the overall perception. This shows that students’ perception of their achievement is different than what is actually true. Most students placed themselves as having only a basic, level 3, understanding of the concepts, while most achieved proficient scores, 3-4, in the portfolio. This can be attributed to many other uncontrollable factors, such as the time lapse between finishing the unit and students completing the post unit questionnaire, use of SIOP notes in both classes, and the upcoming spring break students were anticipating.

**Limitations**

The limitations and threats to validity from this study were numerable. Due to the lack of time, class size, student attendance, and participation issues. In my methods section I discussed possible form of threats to validity and limitations. Looking at my unit now, I can say that the shortened time frame limited my intervention students’ exposure to the SIOP strategies. Had I extended this study to seven or even eight weeks, I feel that students would have had a stronger perception of the improvements that the strategies were creating. Unfortunately, during this unit I lost students from both my control group and intervention class. This caused my numbers to fall
from my pre-unit questionnaire to my post unit questionnaire. Due to attendance and the time of year many students were not able to take the post questionnaire on time or at all, causing those numbers to drop even more drastically. This caused me to extend the time frame for two weeks, so that I had a valid number of students from each class represented in the post unit questionnaires. This means that my post unit questionnaire answers showed students feelings ranging from the end of the unit till week after spring break. Which means students could have forgotten information, been demoralized by their portfolio grades or just not cared at the point in time they took the survey.

My personal bias were very limited in this study because I used student ID numbers instead of names throughout the entire unit. It was harder to address my personal bias as I read through the interviews, because I had chosen the six interview students based on set scores, but had to ask for volunteers when students refused. When reading through interviews my bias came into effect as I asked clarifying question of students. Those students who were open to discuss the unit with me were given more time to explain; while those who choose to barely answer, even when prompt, I chose not to push for more information.

**Action Plan**

In the future I hope to continue this research. Though I saw achievement from my intervention course in comparison to my control group, I did not see the intervention groups' perceptions change, which was the goal. To further this research I would need more time to set up multiple units using the SIOP model lesson planning tools and the NGSS to base those lesson on.

At my site we have a data team, which implements new strategies in the classroom. I would like to help my fellow teachers to try these strategies in their own classes due to our schools
demographic. It would be interesting to see how students improve their academic language and science content understanding over the course of a whole year, rather than just one five-week unit.

**Conclusions**

Overall, my research questions were answered, but not in the way I was expecting. I had hoped to see students in the intervention course see their comprehension levels change at a higher rate, but did not see that. Instead, I found that my Biology students were caught in the neutral zone of the Likert scale, due to their being five options for them to choose from. It was interesting to see that both the science content information and academic language did improve significantly in comparison to the control group, the control group also improved and had high scores in the area of organization in comparison to the intervention course. Further studies are needed to see how students perceive their comprehension change through the use of an intervention, such as the SIOP model.
SIOP STRATEGIES IN THE SCIENCE CLASSROOM

References


Collier, A. (1987) *Age and rate of Acquisition of second language for academic purposes* Tesol Quarterly, vol.21, No.4. pp.617-641


SIOP STRATEGIES IN THE SCIENCE CLASSROOM

Echevarría, J. (2012). Effective practices for increasing the achievement of English learners. *Effective Practices*


48
Taboada, A. (2011). *Relationships of general vocabulary, science vocabulary, and student questioning with science comprehension in students with varying levels of English proficiency.* Springer Science + Business Media B.V.


Appendix A

Pre-Unit Questionnaire
Genetics Unit

Over the next several weeks we will be working on addressing the New Generation Science Standards for Inheritance and Genetics. The standards covered will be addressed in this Questionnaire.

Write Down your Students ID Number

What is your age?

What Block are you in?

- 3
- 5

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What does this standard mean to you?

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What do you not understand?
The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas.

- The science content
- The academic language

Rank yourself on how well you feel you comprehend with standard 1.4. Use a model to illustrate the role of cellular division in producing and maintaining complex organisms.

1 2 3 4 5

Strongly Agree C C C C C Strongly Disagree

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What does this standard mean to you?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
from parents to offspring. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- The science content
- The academic language

Rank yourself on how well you feel you comprehend this standard

3.1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

1 2 3 4 5

Strongly Agree C C C C C Strongly Disagree

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What does this standard mean to you?

The NGSS standard HS-LS-3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What do you not understand?

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations...
through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- [ ] The science content
- [x] The academic language

Rank yourself on how well you feel you comprehend with standard

3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

1 2 3 4 5

Strongly Agree [x] [x] [x] [x] [x] Strongly Disagree

The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What does this standard mean to you?

The NGSS standard HS-LS-3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What do you not understand?
The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- The science content
- The academic language

Rank yourself on how well you feel you comprehend with standard 3.3:

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

1 2 3 4 5

Strongly Agree  C  C  C  C  C  Strongly Disagree
Appendix B

Pre-Unit Questionnaire Response Summary
Summary

Write Down your Students ID Number

368649 4400279 348626 601145 369034 2901457 308636 601090 418673 369614 418536
378343 2901652 318717 359134 309008 348594 348945 308641 448757 398810
308386 359099 348642 368758 2901348 149390 348636 448745 378399 368609
418629 348517 448983 3400976 308579 381287 458573 398787 381537 308864
358779 378682 449390 359039 398901 458589 308562 458581 358510 418508
348610 348656 478826 2902450 2901408 308963 368713 318746 368658

What is your age?

1 7 15 16 14

What Block are you in?

3 51 58%
5 37 42%

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What does this standard mean to you?
This standard states that cellular division replicates itself. It demonstrates natural selection in nature, and the role it plays with organisms evolving to fit their environments better. Nothing the next generation developing. I don't know. I don't understand. Cell division makes organisms. Cell division makes organisms. Using examples of cellular division explains how the genes are passed down to create a complex organism. Being able to draw a model to illustrate the role of cellular division. I don't know. I really don't understand. What were doing. I don't understand. To me, this means to draw about cellular division. Standard to me means its strong. Cell division. I am not sure. I don't know. This means that I need to use a model to illustrate the role of cellular division in producing and maintaining complex organisms. I don't know. Its asking me about the process of the cellular. I don't know. To show how to divide cells. I don't understand. This it mean the division of and caretition and crossing information. They illustrate the role of cellular division. To me, this standard means that it is telling me to use a model that shows a cell dividing or reproducing and staying together. To use a model showing mitosis. To use a model to be able to understand the role in the cellular division. I don't understand very much of this standard. I frankly don't know. This means to me when a parent cell divides and makes a daughter cell. Making models to help a better understanding. I do not know. Being able to draw the role of a cellular division in producing and maintaining complex organisms. This means that you can show others what you have learned by using pictures clearly and interpreting them. Standard means that is right information. In order to learn how this works you must physically see how it works. I don't know. What this means to me. I don't know. I don't understand. It means the study of cells division. I don't know. This standard means to me on how to use models for complex organisms. This means that to illustrate the role of cellular. I have to make something that shows how cellular division keeps organisms alive and helps them reproduce. Mitosis. I don't understand. It I do not know. We have to make something 3d to understand the standard. I cannot comprehend. This means to me that you need to organize the cells. That we will be shown a model to help us understand more about the subject we would be learning about. Cellular division produces and
maintains complex organisms. How we draw how the cellular division is formed and how it holds on to its complex organisms. The next generation. That it will be easier to understand something when it’s show how it happens.

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What do you not understand?

how cells divide everything I dont understand nothing. Nothing i dont know. Nothing How can you show this with a model? I don’t understand complex organisms. I do not understand how cellular division maintain complex organism. I don’t understand how it will maintain complex organisms. I don’t understand the complex organism means complex organisms. How it maintains its complex organisms together. How to illustrate the cellular division. Everything is saying I do not understand anything. I don’t know everything the fact that it says use a model I don’t know. I don’t understand how cellular division maintains organisms. I don’t understand anything I don’t understand much. I don’t understand complex organisms. Nothing I don’t understand everything. Everything I do not understand. What are the complex organisms of cellular division? Cellular division is still confusing for me in general. I do not understand when it says when it says that the cell maintains a complex organism. I understand everything in this sentence. To draw about cellular division based on a model. What types of complex organisms are there and how do you maintain them? Everything All of it. I understand the division part. The cellular division in producing and maintaining complex organisms I don’t know. I don’t understand. Why do they divide and what do they help is on? Why use a model when you can use evidence and or pictures. I don’t know. The maintaining of a complex organism. I don’t understand how cellular division produces and maintains complex organisms. I just don’t get it. I don’t get it. I sort of most likely understand this. I don’t understand anything. I do not know. I don’t understand. How to illustrate the model the whole question I understand nothing. Maintaining complex organisms. It’s not clear for my understanding. The cellular division in...
producing and maintaining complex organisms I'm lost I don't understand how the process for this division occurs. What the NGSS standard is

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?

The academic language 45 52%
The science content 41 48%

Rank yourself on how well you feel you comprehend with standard

1 1 1%
2 11 13%
3 61 72%
4 8 9%
5 4 5%

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What does this standard mean to you?
it means that the genes are getting past to different generations I don't understand what it is trying to ask me. How half of their parents' genes are passed to their offspring. The relationship on DNA and chromosomes coding for traits. I do not understand it. This standard shows how one's heredity passed down and what affected it. I don't know, I don't know. This standard means to me how asking questions help to ask questions? Nothing. If you don't understand anything based on this standard, ask questions I don't know. That to be able to understand and clarify DNA. Knowing what the function of DNA is. It means the generations of humans I don't know, I don't know? How we are made I don't understand the question the genetics that are passed on from generation to generation. It's about DNA and chromosomes in coding the instructions for characteristic traits. I have to really know how DNA codes to how the offspring resemble the parents. To understand clearly I don't know, I don't understand because I don't get how standard has to do with DNA. Chromosomes why are chromosomes passed on? This tells me that I need to ask questions if I do not understand the cycle of DNA. Cartistic making person unique. It means genetics and the offspring receives 50/50 from each parent. It means that half of your mom's and dad's is in your DNA. I do not know. How the genes are passed down to there offspring and how there characteristics they might have genetics and heredity. This means that I need to ask a question to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristics traits passed from parents to offspring. How they change. How the DNA and chromosomes are passed down to there offspring. How they'll look like or have characteristics of the parents' genes that where passed down. Each parent passes down half of there genes to there offspring. Ask questions to understand and to get more information. That both sperm male and female make the baby. It means that DNA is passed on from your parents. I don't know what this means to me. Parents pass traits to offsprings standard means something solid. How half of their parents' genes are passed down to their offspring. I don't know, I don't understand. I don't know asking questions about how DNA and chromosomes relate how they change physique or even mental according to the DNA everyone has some cells from parents I don't understand it to me this means that I have to ask a
question about how DNA, chromosomes, and characteristic traits are passed on from parent to children. What traits and characteristics get passed on to the offspring. To ask questions on DNA and chromosomes in coding the characteristic traits that parents pass to their children. Nothing. It is asking to clarify any problems or concerns regarding the subject. It's asking me what are the physical traits passed down from generation. It means that the characteristic is passed to the parents. It means that like you get some traits from both parents like 50/50 from each. I understand that the offspring will get traits from parents.

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?

everything I understand this standard. I don't really understand what is offspring, and how it works. What to do I don't understand the chromosome part. I don't understand the coding. What is the role of DNA? I don't understand coding the instructions. I don't know I don't know. Nothing. What's the role of DNA and chromosomes? I can't remember maybe next time. The offspring part. I don't understand the relationships. I do not know about this topic. So I don't understand anything about this standard. Everything the coding. I understand that parents pass down chromosomes and DNA to an offspring. None I don't know I don't understand anything. The concept of traits is a bit unclear. Everything. The characteristic traits I think I understand what's being asked. I don't understand the chromosomes. I understand that the parent passed on a sperm to the egg. Nothing I get it. I understand I don't understand that the relationship of chromosome and the DNA. How it works I just don't understand this. Coding instructions. There are long words. None. The difference between DNA and chromosomes. I do not understand where it says NGSS standard 3.1. I completely understand it well. I don't understand the coding of the genes being passed down. Everything I don't understand how they divide. I don't know I don't understand. I understand that we get half of our genes from each of our parents. That make up us as a human as a individual. The chromosomes and coding. How do parents pass to offspring? I don't
know I don't understand how the DNA and chromosomes code for traits. some things I understand everything on this question. I do not understand i do not know How it's passed from parents to offspring Ask questions to understand how DNA and chromosomes code the characteristic traits that parents pass to their children I can't seem to remember right now , sorry maybe next time I'm unclear idk the codes The coding instructions for characteristic traits how are yhe characteristic traits passrd from parents to offspring?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What is more confusing for you in this standard, the academic lanauge or the science content?

The science content 41 49%
The academic language 42 51%

Rank yourself on how well you feel you comprehend this standard
The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What does this standard mean to you?

How many ways babies can be produced. Nothing i dont know this. We have to pick a side and defend it and try to make people change their mind so they can think of it your way. its asking me what can go wrong in most of this I don't know Make a claim based on evidence i dont know How one might get different genes depending on many things. I don't get this standard. All the complications that can occur while genes are being passed down. I'm not sure i dont know. I don't know. It's about evolution(maybe) It means that you can get mutations that suit your environment and that it could be good or bad to me this standard means that i have to make a claim about how genetic variations are a result from new genetic combinations through meiosis, variable errors occurring during replication, or mutations caused by environmental factors. That you have to make a claim based on evidence you have gotten. What could go wrong during genetic changes Standard means pure. I only understand that its talking about changes Idk i don't know i dont know evidence of genetic combinations This standard means to me that we have to write an essay mistakes that happen during mitosis how the new genetic combinations go threw the process of meiosis or the errors that occur during the replication and the mutations are caused by environmental factors nothing the dna can be defective and make the host have a disability Genes are passed down by parents i must back up my results with evidence and facts This means that I have
to make a claim based on evidence that inheritable genetic combinations may result from new genetic combinations through meiosis, viable errors occurring during replication, and mutations caused by environmental factors. Genetic variation means all the different scenarios that take place for natural selection and the variation that occurred. I read about this, but I don't know how to explain it. I don't know what I don't understand. How does the genetic code through the process of meiosis? What types of errors happen during replication, how the mutation happens during the environmental factors? That a problem and change may occur by the things around you. I don't know. I read about this but I can't explain it. I don't understand this DNA and genetic. The steps of something. There's mutations that could happen in our DNA. I do not understand that change in the evolution as a DNA error is passed on. This standard is something I don't understand. To try and validate our claim about genetic variation, pick one of the claims and support it with evidence. Disease I do not know. To back up a claim with evidence that inheritable genetic variations occur from new genetic combinations through meiosis, viable errors occurring during replication, mutations caused by environmental factors. I don't understand. It means that the genetic is combined with the meiosis.

The NGSS standard HS-LS-3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What do you not understand?

I kind of understand mutations. Everything viable. What are some mutations I don't understand? How do these affect our long time traits? I would like to learn more about this so I can understand it better. Mutations I don't know. I don't know. Nothing I don't get this standard. None. I don't understand the first part. I don't understand any of this content. I do not understand where it says the NGSS standard HS-LS-3.2.

Everything this is about I don't understand anything. The genetic variation. Number 3. Everything. Most of it. I don't know. I don't understand anything.
I don't understand most of the standard I will like to learn more about this & be able to understand better I'm not sure Why they gave us the three steps on genetic variations. What's being asked. What environmental factors cause this I do understand what you are asking i dont understand everything How would you defend your claim I still don't really understand the whole thing I understand everything on this question I dont understand the new genetic combinations through meiosis. What do you mean by environmental factors i understand that errors can happen during meiosis To back up a claim with evidence that inheritable genetic variations happen from all the following possibilities. all of the subjects i understand most of it I dont know i dont understand I don't know I dont comprehend this. nothing I understand this Some things i dont understand this content. The steps I didn't understand genetic make variation results. how are mutations caused by environmental factors? i dont understand most of this standard How the mutations are caused by environmental factors idk The content of the subject i dont understand . 1-3 confuse me because i don't understand how they are inheritable. I need to be clarified about how to make a correct claim using information. The evidence

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What is more confusing for you in this standard, the academic language or the science content?

The science content 37.47%
The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

What does this standard mean to you?

There are different traits in populations. How a population got different traits. Show how population has changed. I don't understand. You have to look at percentages and differences. I don't know. I don't know. I don't know. I don't know. I don't know. I don't know. I don't know. I don't know. I don't know.

We see how facts and statistics affect our heredity. I'm not quite sure. I don't know to me this standard means that I have to explain the variation and distribution of expressed traits in a population using the concepts of statistics and probability. This means that I have to apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

I have no clue. This standard involves math and you have to understand math in order to understand the science genetics in populations. Using statistics of traits throughout the population to explain the variety of traits. Its mainly explaining variation. Graph the difference. To know how traits differ in a population. To explain how there population in there environment increases and decreases. To use what you know to explain population traits. I cannot comprehend. How the variation and distribution is expressed in traits for a population. I don't know. I could put my traits into statistics.
i don't understand how the population decreases & increases. How the variation and division of the traits in a population are caused or the process. Variation and distribution I don't know what this means. Too me is that how population affects the world. This standard shows the growth and change of population. It pass from generation to generation. I don't understand this. I do not understand. Have evidence to what you are trying to state. I do not know. Nothing I don't understand. It to have evidence and the will to be able to explain what is happening. It's asking me of what the percentage of a community/population to get the same physical appearance. To explain Standard means something that is right/pure solid. I do not know. This standard means to me a graph use facts. To be detailed with the traits in a population. To apply the concepts of statistics and probability to explain the differences and distribution of expressed traits in a population. How are generation will be in the future.

The NGSS standard HS-LS-3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What do you not understand?

How do they find a way to adapt to their environment everything I understand this all of it.

everything. How many traits in a population. What is distribution of expressed traits. I did not learn this. Nothing how does distribution occur in a variation? I don't know. I don't know. Nothing I understand it not really that good. I don't know. The expressed traits in a population. Do not understand everything. I'm unsure. I do not understand where it says the NGSS HS-LS-3.3. I don't understand how using traits distributed in the population expresses variety. I don't know. I don't understand anything. I don't know which statistics we have to apply. How its expressed or explained in the distribution in a population. Nothing half of it. I understand everything. Everything expressed traits how it trait in a population. I don't understand the question. I understand this concept. I don't understand anything in this content. I don't know. I don't understand. What expressed traits means. I don't understand the entire standard. I don't know. I don't understand everything.

"variation and distribution of expressed traits in a population." Academic
language. I don't understand what specific traits should be explained. I understand everything on this question. Some things statistics and probability To apply the concepts of statistics and probability to explain the differences and distributions of expressed traits in a population. How will statistic and probability will be used. I dont get what variation is. The statistics and probabilities The variation How do they find a way to adapt in there environment so they can find a population to grow idk I do not understand what you are asking I dont understand how to express the traits. The standard I don't understand the expressed traits How to apply them.

The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

What is more confusing for you in this standard, the academic language or the science content?

The science content 36 47%
The academic language 41 53%

Rank yourself on how well you feel you comprehend with standard
SIOP STRATEGIES IN THE SCIENCE CLASSROOM

1 5 6%
2 13 17%
3 39 50%
4 16 21%
5 5 6%
Appendix C

Portfolio Rubric
## Genetics Portfolio Rubric

<table>
<thead>
<tr>
<th>Points</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization/ Neatness</strong></td>
<td>Was unorganized, had not order to the information submitted, did not use table of contents page, work was not readable</td>
<td>Work was mostly unorganized, had a strange order, tried to use table of contents, work was semi-readable</td>
<td>Work was slightly organized, had an order that was detectable, tried to use table of contents and work was mostly readable</td>
<td>Work was organized, had an order that was defined, mostly used the table of contents correctly, and work was readable</td>
<td>Work was organized, had a set order that was very clear, used the table of contents correctly, and work was readable</td>
</tr>
<tr>
<td><strong>Content Information Class work</strong></td>
<td>Student did not use any of the content information for their class work or it was missing all together</td>
<td>Students had 30-60% class work included and what was there had the incorrect content information</td>
<td>Student had 61-75% of the class work included and had about 65-79% of the content information correct</td>
<td>Student had 76-89% of the class work included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the class work and it was 90-100% correct</td>
</tr>
<tr>
<td><strong>Content Information Labs</strong></td>
<td>Student did not include Labs or what was included was under 30% correct for the content information</td>
<td>Student had 30-60% of the labs included and the majority of the content information was incorrect</td>
<td>Student had 61-75% of the labs included and had about 65-79% of the content information was correct</td>
<td>Student had 76-89% of the labs included and had about 80-89% of the content information correct</td>
<td>Student had 90-100% of the labs and it was 90-100% of the content information was correct</td>
</tr>
<tr>
<td><strong>Academic Language Class work</strong></td>
<td>Student did not include class work or what was included was had less than 30% of the required academic language (10 words per assignment) or all words were miss used</td>
<td>Student had 30-60% of the academic language included and had 31-64% of the required academic language used correctly</td>
<td>Student had 61-75% of the academic language included and had about 65-79% of the required language used correctly</td>
<td>Student had 76-89% of the academic language included and had about 80-89% of the required language used correctly</td>
<td>Student had 90-100% of the academic language and 90-100% of the academic language was used correctly</td>
</tr>
</tbody>
</table>
### Appendix D

Post Unit Questionnaire Responses
Post Genetics Unit
Over the next several weeks we will be working on addressing the New Generation Science Standards for Inheritance and Genetics. The standards covered will be addressed in this Questionnaire.

Write Down your Students ID Number

What is your age?

What Block are you in?

- C 3
- C 5

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What does this standard mean to you?
The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What do you not understand?

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- [ ] The science content
- [ ] The academic language

Rank yourself on how well you feel you comprehend with standard 1.4 Use a model to illustrate the role of cellular division in producing and maintaining complex organisms.

1 2 3 4 5

Strongly Agree [ ] [ ] [ ] [ ] [ ] Strongly Disagree

Do you think your understanding of this standard increased?

1.4 Use a model to illustrate the role of cellular division in producing and maintaining complex organisms.

1 2 3 4 5

Strongly Agree [ ] [ ] [ ] [ ] [ ] Strongly Disagree

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What does this standard mean to you?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- [ ] The science content
The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What does this standard mean to you?

The NGSS standard HS-LS-3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What do you not understand?

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas.

The science content

The academic language

Rank yourself on how well you feel you comprehend with standard 3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

1 2 3 4 5

Strongly Agree

Strongly Disagree

Do you think your understanding of this standard increased?

3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

1 2 3 4 5

Strongly Agree

Strongly Disagree
The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What does this standard mean to you?

The NGSS standard HS-LS-3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What do you not understand?

The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What is more confusing for you in this standard, the academic language or the science content?

Academic language is the more complex words used universally throughout all content areas

- The science content
- The academic language

Rank yourself on how well you feel you comprehend with standard 3.3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

1 2 3 4 5

Strongly Agree

Do you think your understanding of this standard increased?

3.3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

1 2 3 4 5

Strongly Agree

Explain in your own words the strength and weakness of the intervention you experienced and why.

Appendix E

Post Unit Summary of Responses
Control Group Post unit Questionnaire Results

29 responses

Summary

Write Down your Students ID Number
What is your age?
17 15 16

What Block are you in?

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What does this standard mean to you?

This means that we have to illustrate a model to see the role of cellular division. It means the process of how cells divide. I don't understand this means to me how the cells divide into two. I don't know nothing. Use a model to show the role of cellular division in producing and keeping complex organisms. This standard means that they are many cells that divide in different parts. I do not understand illustrating the role of cellular division by producing & maintaining complex organisms. I don't really understand this a lot. That cellular division
produces and maintaining of complex organisms. This means I me to build a model and show people how cellular division works. It means to build a project that would represent all of this. This standard means that I can picture an imagine In my head and I can't build a model for it. It means to me to build a cell and and show the people how the cellular division works. I don't know it means to me that cells grow more and more by producing them. To use a model to explain organisms. It means nothing. Use something that can represent how cellular division produces and maintains complex organisms. To draw the cycle of a cellular division in making and keeping the complex organisms. Nothing it means nothing. It means the division of a cell by mitosis or meiosis.

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What do you not understand? Everything I understand everything. I do not understand what you are asking me. How you maintain them. I don't know division i producing i dont understand the complex organism means. I need to learn more about this. The language I do not understand this a lot. The complex organisms I don't understand anything. The design of the model how it divide and how it keeps its order. Everything I don't understand the language i understand most of it. I don't know why we have to illustrate what the role is. I understand everything I don't understand how some cell division happens. I understand that I am the one that missed some days of these lessons so I don't completely understand it. The way it is written. maintaining complex organisms I understand a little bite. Cellular Division Everything.

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?
The science content
2 3%

The academic language
5

6 7%

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What does this standard mean to you?
that DNA and chromosomes in coding the instructions for characteristic traits passed down from parents. I don't know how the parents' genes or traits get passed down to their offspring and how many chromosomes or gender they might have. How DNA and chromosome are in relationship. Ask questions to understand relationships about the role of DNA and chromosomes in coding the instructions for characteristics traits passed from parents to their kids.

Chromosomes give us the traits we have. This means to me that a male and a female are having a baby. What I understand is that we have to ask questions to be able to understand more about what we are talking about. How genes are passed down I don't know I understand. That you get both genes from your parents. How their parents' traits get passed on I do not understand. To ask questions that will better help us understand this, to ask questions I don't know that you know how to code a DNA strand I don't know. I must ask questions if I do not understand. I now know how to label DNA and what it does. Being able to ask questions that can clarify relationships about the way DNA and chromosomes work to code for instructions of traits than can be passed down to offspring. This means that characteristics are passed by to the next.

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?

The role of DNA Chromosomes I understand everything. I don't know nothing. I know almost everything I do not understand what this is asking. How to code the chromosomes. I know this nothing I understand I understand most of this standard. I don't understand anything I don't understand the possess. I don't understand that how they move. Nothing I understand. The way it is written. Everything I don't know I don't understand how offspring was passed before passing it
on, some of it I understand. what is the role in chromosomes in the dna strand? I am not sure there is something that I don't understand.

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What is more confusing for you in this standard, the academic language or the science content?

The science content 3%
The academic language 6 7%

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

What does this standard mean to you?

Make a statement that you can back up about inheritable genetic variation. I don't know I don't know Nothing Come up with and back up a claim based on evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and mutations caused from environmental factors. I now how genes are transferred and what they do. I also know how genes are passed down and how genetics work and also how mutation occurs. I understand Instructions or results of genetic variations. this standard is talking about genetics and DNA i don't understand nothing the new genetic combination work together with meiosis. the natural selection how the traits if organisms develop over time. I do not know. need to learn more of this I dont know i dont understand

Number 3 Mutations can occur in the DNA of a child I don't know It means to me that errors, genetic combinations, and mutation happen when a baby is being developed in the female's stomach I don't understand it This means that we have to understand ans or make a claim based on what evidence and what you are learning about.

The NGSS standard HS-LS-3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What do you not understand?
everything The way the mutations occur I don't know I do not understand what this is asking i dont understand this Everything Number 3. I don't understand anything Factors The 3 steps. Number 2 2 hiw the natural selection happens I don't understand. The way it is written. Need to learn more about this need to learn more of this i understand most of it I don't know nothng i dont understand the mmeaning they way its explaining. I understand everything

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What is more confusing for you in this standard, the academic lanauge or the science content?

The academic [14]

The science [13]

4

The science content

3 8%

The academic

5

language

4 2%

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What does this standard mean to you?

I don’t know I don’t know I don’t know Need to learn more. Nothing To be able to understand the expressed traits in a population we have to apply statistics and probability to explain it. I don’t know. Determine the genotype and phenotype of an organism I understand Learn more it is asking what are the expressed traits in a population Use statistics and probability to explain the variation of traits in a population to explain I don’t know It means that it list the above I don’t understand I don’t know how the variation and distribution of traits get in population People in our generation or population. I actually understand this and I am confident about doing it. that the variation and distribution expresses traits in a population.
The NGSS standard HS-LS-3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

What do you not understand?

The variation of traits everything i don't know I understand most I don't know Expressed traits. Everything I don't. The Phenotype and Genotype of an organism Learn more i forget things but i know what im learning if i make sense the statistics and probability explin more about this I don't understand anything nothing Everything The way it is written and what it is asking. i dont understand I don't know apply concepts of statistics I understand everything i don't understand the prosses How the variation and distribution I did not understand nothing. I don't get it

The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What is more confusing for you in this standard, the academic lanauge or the science content?

- The science content: 4
- The academic language: 5

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
Explain in your own words the strength and weakness of the intervention you experienced and why.

I understand some of it I don't know. Some strengths are that genetics are something I really understand and I can explain well. Some weaknesses are that I did not get as much practice with the subjects as I would've liked to have. The strength was so difficult. I don't know too much of these Idk. How the variations and how the traits get passed down I experienced that DNA is complicated. The academic language is confusing at times but if I read it thoroughly I understand. I don't know. The strength of this intervention was on how things and organisms change over time and the weakness are the explanation on how everything happens, how evolution challenges. Need to learn more about this? How the variation and genes get passed down or how the natural selection happens in an environment I don't know. There was many strengths and weaknesses during this topic. Like how I didn't know what to do some times, and other things I knew from past classes. I get how the variation and traits work but then I forget it was good, because it was
easy and simple i understand most of the material learning this helped me in life and genes and dna and my weaknesses was mostly the vocabulary

**Intervention Group Post unit questionnaire**

27 responses

**Summary**

**Write Down your Students ID Number**

368649 358439 601145 2901457 378343 318717 359134 309008 359098 448745 378399
368609 418629 448983 308864 398788 359039 458583 458581 358510 478826 308963 318746
478733

**What is your age?**

17 15 16 14

**What Block are you in?**

7 00%
The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What does this standard mean to you?

This standard shows how cellular division is used to change in order to keep the organs good. That the cell divides and clones itself. I don't know I don't know. This means that I can show how cellular division occurs and how it produces and maintains complex organisms. It means that the complex organisms are maintaining. Draw a picture or model to explain the role of cellular division other than in words. I don't know. As mutations and drift occur in cellular division, differences arise in the person's genes and their phenotype begins to differ from their families. Something about the cells. It means a lot. Find a DNA model. It means that we will learn about cellular division through models and examples. This means to me that cells need to divide to maintain complex organisms alive and to help them evolve. Cellular division produces and maintains complex organisms. We have to do a model on cellular division. How cellular division makes complex organisms. This standard means that the role of division should be showed by using a model. To use a model and illustrate I understand this concept of cellular division. It's pretty easy. To me it means that cells are divided by cellular division. That way the can produce and maintain the organisms. To show how the structure functions and to demonstrate where the parts are located and how they help with the system.

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What do you not understand?

A complex organism needs more clone cells. I don't understand this can't explain. I understand everything. I don't understand what model it's talking about. I don't know. Nothing Cellular. I don't understand the model to illustrate the role of cellular division. A little I don't understand how
the model should be done. I don't understand how cellular division is producing I fully understand all the concepts of this standard The maintaining complex organisms everything using a model to illustrate mostly everything how do I illustrate this? I don't know I understand this standard I understand everything how to illustrate the role That's it might be easier to understand when using models I don't understand the vocabulary used in this standard.

The NGSS standard 1.4 reads as follows: Use a model to illustrate the role of cellular division in producing and maintaining complex organisms. What is more confusing for you in this standard, the academic language or the science content?

The academic [15]

The science [12]

The science content 2 4%

The academic language 5 6%

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What does this standard mean to you?

This standard means that I can tell what the relationship is between DNA and chromosomes which are the ones responsible for characteristics for traits passed down from parents to offspring. I don't know. It means that you have to participate and ask for help. This means to me that we need to be sure of the process on how chromosomes interchange chromitids during intercourse so that the offspring have traits both parents. The alleles then decide the phenotype of the offspring. Parents pass some characteristic traits to their offspring. We have to ask questions to show the relationship about DNA and chromosomes. It codes for the life of a human being. This standard means if you don't understand the relationships about the role of DNA and chromosomes, then you should ask questions in order to have a better understanding. DNA and chromosomes vary the characteristics of a person's traits and what they function for. I think this standard is pretty hard, but most parts are pretty easy. DNA is important to us because we carry the genes of our ancestors. Family. To understand how parents pass their traits to the offspring, every organism has their own DNA coding. It means how DNA passes through other people as in characteristics the standard means that the genes that the parents have will allow it to the spring to get specific characteristics. Also, chromosomes and DNA both have similar but in a way different coding, but both help our organism stay strong and protected. The chromosomes your parents passed you DNA and
The role of DNA and characteristic traits: What DNA is and how it gives our characteristics from our parents. Idk the genes. It's telling me to explain the similarities shared by DNA & chromosomes.

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What do you not understand?

Some what type of questions? Be more specific. I'm not sure what it's asking for. I think I understand i understand perfectly i dont know I don't know i understand everything. It's hard for me in the big pun net squares i kindha understand it to ask questions about the relationship The coding instructions I don't understand the types of questions should be asked. nothing. What are the instructions for characteristic traits? How do parents pass it through offspring? Why are we the offspring of the parents? I need a better understanding of the process just to clarify it better. I have nothing further in this subject. I understand everything. Why do they restate the coding instructions it just confuses me. The coding idk.

The NGSS standard 3.1 reads as follows: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. What is more confusing for you in this standard, the academic language or the science content?
The science content  

The academic language  

Rank yourself on how well you feel you comprehend with standard

Do you think your understanding of this standard increased?
The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What does this standard mean to you?

It's showing me the results that could happen in genetic variation to make a claim based on the evidence that are given. I'm not understanding this clearly. I don't know how to defend your claim about a certain mutation. How we get unique and different DNA that codes our traits. This
standard means that you have to state your claim and support it with good evidence about one of those topics. There are many factors that come to place when DNA is being passed down from parent to baby. The effects each mutation have on the organism defines it. It means a lot That viable error or mutation can affect the evolution we need to pick one of the three and defend the claim explaining how traits are passed from parents to offspring. you can explain this with mutations and errors while replicating. This standard means that i understand hoe genetic variation and mutations occur. make and defend claims I think these concepts are pretty easy the meiosis concept sometimes gets confusing 1.idont recall dis subject 2 some dt can ocute is mutations deletons ect. 3 this is called evolution based on itz habitad Meiosis is when new genetic combinations are made and some times mutations occur. It's hard to replicate someone and it takes time and there might be some errors The errors What is inheritable and what it will result from idk

The NGSS standard HS-LS-3.2 reads as follows: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. What do you not understand?

how errors occurre The fact that visible errors occur during replication Don't understand what's the correct result i dont know Nothing I don't understand how a claim should be started and done. I have trouble making a claim that is strong and applies to the evidence used. Nothing really The results Idk The new genetic combination i don't understand number 2 Viable errors nothing said all I can in first part i dont understand the genetic variations I don't understand how errors occurring during replication (2) what are mutations caused by environmental factors? like
adaptations to survive? I understand everything what are environmental factors? Mutations
caused by environmental factors. What environmental factors?

The NGSS standard 3.2 reads as follows: Make and defend a claim based on evidence
that inheritable genetic variations may result from: (1) new genetic combinations through
meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by
environmental factors. What is more confusing for you in this standard, the academic
language or the science content?

The science content 3
The academic language 0

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What does this standard mean to you?

I don't recall this subject. Using data to understand the variation and diversity among a population. I don't know. Nothing this means to me that we have to do a Punnett square and calculate the phenotypes in a population and the future possible phenotypes. It means a lot to explain the variation and distribute traits. It's asking to use what I know on expressed traits in a population. Find the percentages and math to support what you say. It has impact in the population. I really don't know what this standard is like what we did for it but we can express the fact that there is variation in species over time and better traits. How different traits create different kinds of variation in a population. To apply concepts. This standard means that you need to apply a concept to explain the variation and distribution of expresses traits. The traits in species populations. The population of concepts of the variation every organism look and have different traits. How a population gets it's traits it means to me how expressed traits in a population. How traits are passed on from generation to generation. Variation and distribution affect traits in a population. I don't know.

The NGSS standard HS-LS-3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What do you not understand?
Some I don't understand distribution Nothing I don't understand how to use the statistics and data in order to conclude and express the traits distributed in the population. I don't know Nothing I don't understand how to explain the topic and apply the concept. What variations? the distributions of traits in a population I don't understand about the NGSS I don't know nothing The expressed traits in a population How to apply concepts how do we apply statistics to this? do we make it into like a graph? everything Distribution of expressed traits I understand everything I don't know how to express the concepts of stats into the population and expressed traits I don't know how to apply them

The NGSS standard 3.3 reads as follows: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. What is more confusing for you in this standard, the academic language or the science content?

Rank yourself on how well you feel you comprehend with standard
Do you think your understanding of this standard increased?
Explain in your own words the strength and weakness of the intervention you experienced and why.

I believe my weaknesses are the projects and my organization. My strengths are the note taking and comprehension of this unit because I can explain a lot of the information. The science content in the questions is pretty hard. These couple of months, the concepts I learned have affected my opinions in how the world see mutations. Also the importance for scientists to keep discovering the mysteries hidden among our DNA. It was difficult for me to clearly state my stance on all the controversial topics we explored. The academic language it's hard to understand. My weakness for this intervention was that I didn't get it a little bit. I did understand what each standard was meaning, but I need more explanation so that I can explain it to others. I understand some, but the vocabulary confuses me. It was difficult because I don't study. I can't say anything yet. There were a lot of sharp right and left turns and can't get through it but a bit if made me a bit better. The scientific words they confused me because they are all hard to say and remember.
what they do The strength was learning new things but my weakness was remembering the new subjects and vocabulary. I liked working with punnett squares and making "real babies" calculating the genotypes and phenotypes was fun. I had trouble understanding the academic language. The intervention I've experienced has given me the strengths to develop new learning skills. My weakness is the fact that there are times that we have to both learn and do work independently. I don't have a weakness I don't know the strengths an weaknesses it's seen like we've been doing by most the same stuff all year have lost of blanks in my head dont understand lotz of things in science They made the wording to complicated I like it short and simple its was hard The scientific concept because I understand the worlds but not the point of the standards I don't know how explain it
Appendix F

Student Interview Questions
Interview Questions

1. What from this unit was the most confusing, the academic language or the science content? Why?

2. From the New generation science standards (NGSS) what was your major challenge throughout the unit?

3. During the intervention what made you feel like you understood the content better?

4. What experience(s) during the intervention made you feel less successful? Why?

5. After having gone through the intervention, what have you learned about genetics and inheritance?

6. Do you level do you feel you reached of comprehension? Why?
   a. Far below average
   b. Below average
   c. Basic
   d. Proficient
   e. Advanced

7. If you could change any one thing during this intervention what would it be?

8. Do you feel that after this intervention you have learned more academic language as well as the content?

9. Do you have any questions for me or comments that you feel are important to this study?
Appendix G

Student Interview Responses
1. The hardest thing to understand was the proofs for the crosses. Like the Punnett squares.

2. The major challenge was to be able to use the academic language. I just don't get how it is used all the time, some times it's easy.

3. The paper babies lab! I got to apply all the new stuff and it made everything make more sense.

4. The practice packets we did individually. Those were just too hard.

5. I learned that how genes are passed and the probability of inheritance leads to things like DNA mutations, genetic diseases and that we get 50% of our DNA and genes from mom and 50% from dad.

6. I'd say I'm advanced (E) I can explain it well to others and use my own words to do it.

7. More hands-on activities and videos like the documentary clips you showed that are awesome!

8. Yes, I guess so. I think I have a strong knowledge as is.

9. More time to practice with you and groups.
1. The science content was most confining for me because I did not understand any of this at first so everything was new to me.

2. The major challenge was learning everything quickly when I did not know anything. But overall there was not any major challenges for me.

3. The notes made me feel like I understood the content better because I could go back to my notes and I knew they would be there when I need them.

4. The Dihybrid cross was what really confused me because it was so hard for me. Then again I did miss notes on it so I probably would have understood better with these notes.

5. I have learned that genetics are passed through generations of organisms. You inherit your traits from your parents so nothing is passed down. Everyone has different traits. Sometimes there are birth defects and they are normal. We learned about all the types of different genetic diseases.

6. I feel like I am proficient because I can really tell someone about genetics and they would understand what I am saying.
7. I would not change anything because all the subjects were covered exactly right.

8. Yes, I feel that after this intervention, I have learned more academic language and content. All the notes are what helped me get through everything.

9. I do not really have any questions, but my only comment would be that the notes are really helpful and I would very much appreciate if Ms. Plumez would keep doing notes and explaining them the way she does.
1. They both were. The science was more difficult.

2. Staying up. I am kind of slow at homework and there was a lot of it.

3. The notes and the Labs. They made sense.

4. The writing. I am not good at it and I wasn't sure of the answers.

5. That parents pass them down, that I got my eyes from my Mom and Dad. And that we are really complex because of cell meiosis.

6. B. Below

7. Less homework, do more in class and get more help.
8. I learned more science. I am not sure about academic language.

9. Will we see this more?

-No clarification: student left for 2 weeks.
1. What from this unit was the most confusing, the academic language or the science content? Why?

2. From the New generation science standards (NGSS) what was your major challenge throughout the unit?

3. During the intervention what made you feel like you understood the content better?

4. What experience(s) during the intervention made you feel less successful? Why?

5. After having gone through the intervention, what have you learned about genetics and inheritance?

6. Do you level do you feel you reached of comprehension? Why?
   a. Far below average
   b. Below average
   c. Basic
   d. Proficient
   e. Advanced

7. If you could change any one thing during this intervention what would it be?

8. Do you feel that after this intervention you have learned more academic language as well as the content?

9. Do you have any questions for me or comments that you feel are important to this study?
SIOP STRATEGIES IN THE SCIENCE CLASSROOM

N: 5) At this time, probability of inheritance, DNA mutations, cause, helpful or harmful?

N: 6) Passed testing 6 post & how gene are pass the process

N: 5) More hands on activities - more videos, Khan video, Nova

N: 6) More hands on (manipulatives) videos & U. Notes

N: 5) Can Gros out utilize

N: 6) Both can explain rather than assume can explain in terms others know

N: 5) Videos usually work, notes are okay but extra explanation are helpful

Video Notes "o"

N: 5) Good note taking, closed cornell notes

N: 5) More time to pay attention.
My Notes: Angie: Intervention

Interview Questions

1. What from this unit was the most confusing, the academic language or the science content? Why?
2. From the New generation science standards (NGSS) what was your major challenge throughout the unit?
3. During the intervention what made you feel like you understood the content better?
4. What experience(s) during the intervention made you feel less successful? Why?
5. After having gone through the intervention, what have you learned about genetics and inheritance?
6. Do you level do you feel you reached of comprehension? Why?
   a. Far below average
   b. Below average
   c. Basic
   d. Proficient, get test can't explain to others
   e. Advanced
7. If you could change any one thing during this intervention what would it be?
8. Do you feel that after this intervention you have learned more academic language as well as the content?
9. Do you have any questions for me or comments that you feel are important to this study?

1. Science explained was more difficult
2. Different between us & me > order of them
3. 5 slide presentations/ we're doing/ explanation = if
4. Project getting all the info. Articles were confusing
   * Trial supply down
5. All officers have plan need urgency plan from plan
   received.
6. I'd
7. Wouldn't change anything, felt normal more one on one.
8. Yes, @ begin yet though all the s & c. was involved.
2) I feel like I'm basing. I understand mostly all of it and I could explain to someone else but I have some doubts about my answers?

I don't know that I didn't put that first.

If I would change one thing about these interventions it would be to have more notes like when we practice them on the board (Modeling).

4) I feel like I have learned more academic language and content after this intervention. How would you say the intervention helped? I don't know.

5) I have no question about these studies but I would like to go into further research about it.

Ask you do more research?

No, not yet. I want to know more about Mendel though and how we have stronger genes.
Interview Answers

1) The most confusing thing for me from this unit was the science content because of the procedures of the Punnett Square chart.

2) The major challenge throughout the unit were the dy-Hybrid Punnett Squares. Why? Not enough in class practice.

3) What made me understood was the notes we took because I didn't understand a question or the homework I would just look back to my notes.

4) During the intervention I felt less successful because of the Vocable charts. F? There was just too many new words.

5) After going through the intervention I learned that we get 50% of genes from one parent and 50% by our other parent, also that our genes mutate so we can adapt to our surroundings.
1. I feel like I'm basic. I understand mostly all of it and I could explain to someone else but I have some doubts about my knowledge.

   I don't know but I didn't pass the test.

2. If I could change one thing about the test, it would be to have more notes. How? Like when we practice them on the board (modeling).

3. I feel like I have learned more academic language and concepts after this intervention. How would you say the intervention helped? I don't know.

4. I have no question about these studies, but I would like to go into further research about it.

   Ask you do more research?

   No, not yet. I want to learn more about Mendel though and how we have strong genes.
1. The most confusing unit was the genetic unit because I did not understand the Punnett squares.

2. My most challenge throughout the unit was figuring out on the project. Why? Because I didn't get anything!

3. It did not make me feel better. I didn't understand anything.

Punnett squares, how it worked

4. Everything from the unit made me feel less successful because it was too hard.

5. I didn't learn anything it was too hard why? I don't know... I was absent a lot.

6. I feel far below average because the assignments were too advanced for me.

7. If I could change anything it would be the unit and project. How? I don't know your the teacher, maybe make
8) No? mitler I learned nothing

9) It was too hard
... it was just too hard and too much work.
Appendix H

Example Cornell Closed Notes
### SlOP STRATEGIES IN THE SCIENCE CLASSROOM

**Name:**

**Date:**

**Block:**

**Topic:**

<table>
<thead>
<tr>
<th>Questions/Key Information</th>
<th>Notes and Pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENETICS</strong> –</td>
<td></td>
</tr>
<tr>
<td><strong>Chromosomes carry the information (genes)</strong></td>
<td></td>
</tr>
<tr>
<td>+ Arrangement of nucleotides in DNA</td>
<td></td>
</tr>
<tr>
<td>+ DNA → RNA → amino acids → Proteins</td>
<td></td>
</tr>
<tr>
<td><strong>Chromosomes (and genes) occur in pairs</strong></td>
<td></td>
</tr>
<tr>
<td><strong>New combinations of genes occur in reproduction</strong></td>
<td></td>
</tr>
<tr>
<td>+ Fertilization from two parents</td>
<td></td>
</tr>
<tr>
<td><strong>Austrian Monk, born in what is now Czech Republic in</strong></td>
<td></td>
</tr>
<tr>
<td>+ Son of peasant farmer, studied Theology and was ordained priest Order St. Augustine.</td>
<td></td>
</tr>
<tr>
<td>+ Went to the university of Vienna, where he studied</td>
<td></td>
</tr>
<tr>
<td>+ Worked with pure lines of peas for eight years</td>
<td></td>
</tr>
<tr>
<td>+ Prior to Mendel, heredity was regarded as a “” process and the offspring were essentially a “dilution” of the</td>
<td></td>
</tr>
</tbody>
</table>

Mendel looked at seven traits or characteristics of pea plants:
1. 2. 3. 4. 5. 6. 7.

+ **In 1866 he published Experiments in Plant Hybridization, (Versuche über Pflanzen-Hybriden) in which he established his** |
+ **He tried to repeat his work in another plant, but didn’t work because the plant reproduced asexually!** |
+ **Work was largely ignored for 34 years, until , when 3 independent botanists rediscovered Mendel’s work.** |

❖ Mendel was the first biologist to use Mathematics – to explain his results quantitatively.
❖ Mendel predicted
  - The concept
  - That genes

❖ 1. Principle of Dominance:
2. Principle of Segregation:

* we will look at his third principle later on

- Monohybrid cross: a genetic __________ involving a __________ (one trait); parents differ by a single trait.

- \( P = \) __________

- \( F_1 = \) First filial generation;

- \( F_2 = \) Second filial generation of a genetic cross

\[ \begin{align*}
P &= \text{parentals} \\
\text{homozygous plants:} \\
T T \times t t
\end{align*} \]

\[ \begin{align*}
F_1 \text{ generation} \\
is \text{__________}: \\
T t \\
\text{(all __________)}
\end{align*} \]

\[ \text{__________} \text{ is a useful tool to do genetic crosses} \]

- For a monohybrid cross, you need a square divided by __________.,

- Looks like a windowpane...

- We use the __________ to predict the __________ and __________ of offspring.
**Steps:**
1. Determine the genotypes of the parent organisms
2. Write down your "cross" (mating)
3. Draw a p-square

**Parent genotypes:**
- TT
- tt

**Cross:**

\[
TT \times tt
\]

4. "Split" the letters of the genotype for each parent & put them "outside" the p-square
5. Determine the possible genotypes of the offspring by filling in the p-square
6. Summarize results (genotypes & phenotypes of offspring)

- **If you let the F1 generation self-fertilize, the next monohybrid cross would be:**

\[
Tt \times Tt
\]

**Phenotypes:**
- (tall) (tall)

**Genotypes:**

- **Key to the Punnett Square:**
  1. Determine the gametes of each parent...
  2. How? By "splitting" the genotypes of each parent:
Once you have the gametes...

- If either parent is HOMOZYGOUS... You only need one box!