Culturally ConnectED: Bridging Culture and Science through Anchoring Phenomenon

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Abstract

This inquiry project seeks to address how the disconnect between students' lived experiences and science curriculum presented in schools negatively impacts students' motivation to engage in science skills like creating evidence-based explanations. The study was conducted in two College Prep (CP) biology classrooms composed of 71 students total. Student participants were Latin American, Asian, and Caucasian with few reclassified English Language Learners, and two students with Individualized Education Plans/504s. This inquiry investigated the question: How might the implementation of culturally relevant anchoring phenomenon encourage 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment? This inquiry was informed by Gloria Ladson Billings framework of Culturally Relevant Pedagogy (CRP) and was conducted using teacher inquiry. Interventions used in this inquiry were the implementation of culturally relevant anchoring phenomenon along with collaboration techniques and various graphic organizers to aid in creation of evidence based explanations. Data was collected using surveys, student work, a researcher journal, and a focus group. The study found that 1.) CRP increased students' self efficacy for engaging in science skills 2.) CRP allowed for deeper sense making tapping into students community funds of knowledge and 3.) CRP allowed students to extend knowledge beyond the classroom. Based on these results it is recommended that teachers implement an anchoring phenomenon that connects to students' cultures, interests and lived experiences as a means of increasing student agency and allowing students to connect to science concepts beyond the classroom.

Keywords: Culturally Relevant, Phenomenon, Evidence Based Explanation

Introduction

Due to the lack of cultural relevance in the current curriculum, students are often disconnected from the knowledge learned in class to their daily lives. Because it is known that "students' lived experiences, societal inequalities, and internal motivation affect how knowledge is acquired" (Love 2009), it is imperative that science instruction reflects these multiple lived experiences and to aid in the development of internal motivation.

The discipline of science consistently urges students to think like scientists, by using the scientific method of thinking that ultimately starts with inquiry, leading to data collection and observation and finally an evidence based explanation. This is seen everywhere in the NGSS standards but has yet to be reflected in many science classrooms, including the one where this intervention will take place. Since students are not connected to the content, they are unable to engage in the process of scientific thinking as students are not encouraged to inquire about relevant phenomena that connect to students' histories and the subject area. Thus, the topic for this inquiry, is the implementation of culturally relevant phenomena that allow students to engage in their own inquiry practices through the process of analyzing and interpreting data that allow them to not only connect to their lived experiences but also allow them to create evidence based explanations for these phenomena as it is schools responsibility to "support the acquisition of personal and social assets" by means of cultural relevance (Eccles et al. 2002).

Description of Study Context

Interventions addressing the lack of cultural relevance will take place in two CP Freshman Biology Classes at a suburban High School located in Orange County, composed of 35 and 36 students respectively. The students in this class are most familiar with a more traditional style of biology instruction in which the curriculum is based on facts and has yet to be situated in a larger context outside of the classroom. For example, students might learn the facts behind scientific processes and principles but are not taught in a way in which they are encouraged to value these processes and principles and apply these processes outside of the classroom. While students have been successful in terms of letter grades with this approach to instruction, as reflected in their grades, participation is solely grade driven, as students are unable to find other aspects of motivation as there have been none offered to them.

It is important to note that while there is a range of diversity among the class, the majority of students are Latin American(36%), Asian (28%) and Caucasian (18%), which is imperative to take into consideration in regards to finding cultural relevance, as the amplitude of relevance depends on the context and demographic of the classroom. Additionally, many students, although reclassified, speak their native languages when at home and outside of the classroom, with only 2 students having IEPs and/or 504 plans.

Dilemma/Problem of Practice

While students are relatively successful in terms of a traditional grading scale in the classroom, students often themselves are bored and disconnected from the instruction. Encouraging students to participate in the class has become increasingly difficult as the year progresses as students become further removed from the curriculum, as the curriculum lacks any type of relevance relating to students' histories, cultures and lived experiences. This lack of participation is not only a frustration felt by the instructors of the class but felt by the students themselves as they are forced to merely memorize scientific processes and principles rather than truly engage in the process of scientific thinking or ‘thinking like a scientist’. Here, it can be seen that because much focus has been put on the memorization of scientific principles and processes, engaging in forming evidence based explanations and synthesizing information is extremely difficult for students, which might be relieved with the implementation of more relevant anchoring phenomenon that students can use as the basis of their inquiry practices. The dilemma of disconnect between students and the curriculum itself creates barriers to learning as students have decreased ability to access the curriculum in a way in which students can find greater meaning, further perpetuating inequities in the classroom as a noteworthy reason for students academic challenges is that schools have yet to “insert education into the [student’s] culture” (Ladson-Billings 1995).

This inquiry aims to disrupt this disconnect between students' meaning making and the curriculum taught in schools through the implementation of a culturally relevant anchoring phenomena. It is hoped that the introduction of a culturally relevant curriculum will allow students to engage in science concepts more effectively and “think like scientists” through the process of analyzing data to ultimately create an evidence based explanation. Therefore, the wanted outcome of this inquiry is a greater connection between students' lived experiences and the way in which curriculum is presented as culturally relevant curriculum allows students “to move beyond academic achievement to position themselves as transformative intellectual[s]” who “demonstrate complex thinking about science and social justice issues” (Morales-Doyle 2017).

Inquiry Question

How might the implementation of culturally relevant anchoring phenomenon encourage 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment?

Literature Review

Theoretical Framework.

This investigation is guided by the principles as outlined by works that touch on theories of culturally relevant as well as culturally sustaining pedagogy as framed by Gloria Ladson-Billings (1995, 2021) in which it is stated that it its teachers responsibility to cultivate "an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of a sociopolitical consciousness" (1995). Here, the term "culturally relevant" is used to encompass a wide range of student identities that are all embedded within the context of youth culture, as "understanding the power of youth culture" can "transform teaching and learning" (Ladson-Billings 2021). Furthermore, the student identities themselves are multifaceted as they emerge from "participation in historically inherited practices" like ethnicity, nationality and religion, "participating and viewing oneself as a member of particular groupings" such as student self identities of an athlete, a gamer, an artist etc. that align with student interests, and from "influences of how others how others see you" (Lee 2017).

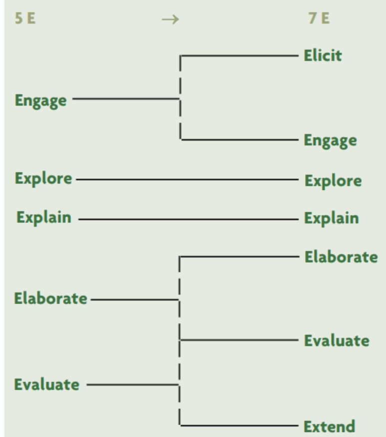
In the classroom context, because students hold ownership over these multifaceted identities that arise from their life histories and from their youth culture, they, along with their teachers, hold values and preconceived beliefs of what "smart" may look like, in the form of "settled expectations" or the "set of assumptions, privileges and and benefits that accompany the status of being white" which seek to "restrict the intellectual and expressive opportunities youth have in school" (Bang et al 2013). For this reason it is imperative that teachers, especially teachers whose students come from diverse backgrounds, not only acknowledge students' multidimensional identities, but also seek to support and encourage students' multiple identities in the classroom through the subject specific content as to not further confirm these narrow "settled expectations". Additionally, to further challenge these "settled expectations" the implementation of culturally rich and diverse anchoring phenomenon will sek to tap into students' cultural funds of knowledge. This "household knowledge" can be defined as knowledge "obtained by the [student], not imposed on by the [teacher]" where knowledge is still content based despite being often overlooked (Genzuk 1999). For this reason, this inquiry will focus on the implementation of a culturally rich and relevant anchoring phenomenon to support students' sense of belonging in the classroom and allow students to find meaning within the science curriculum as "local phenomena and problems rooted in students' experiences and language promote both equity and science and engineering learning" (Lee & Grapin 2022).

Conceptual Framework

In combination with the theoretical framework of cultural relevance, the model in which culturally relevant or sustaining pedagogy will be implemented into the 9th grade Biology classroom will follow the 7E model, an expansion of the traditional 5E model that included the five components of "engage, explore, explain, elaborate, and evaluate." Here, the

FIGURE 1

The proposed 7E learning cycle and instructional model.



“7E model expands the engage element into two components - elicit and engage” and “expands the two stages of elaborate and evaluate into three components - elaborate, evaluate and expand” (Eisenkraft 2003). Thus, the 7E model of instruction is composed of elicit, engage, elaborate, evaluate and expand (Figure 1).

Following the 7E model will support both the implementation of the culturally relevant anchoring phenomenon as well as help students to develop their evidence based explanations. The anchoring phenomenon itself, as it ties into students interests and histories, will aid in engaging students in addition to allowing students to elaborate on science concepts, evaluate data and observations to expand on their learning and apply their knowledge to explain why the chosen anchoring phenomenon occurs or explain the process for the anchoring phenomenon.

Disciplinary Literacy and Practices

The implementation of the Next Generation Science Standards (NGSS) has created a calling for a shift in the way teachers approach science instruction. As opposed to the traditional teaching methods, NGSS is composed of three domains, the Disciplinary Core Ideas (DCI), the science concepts taught in schools, the Science and Engineering Practices (SEP), which “provide students with the skills needed to ask questions” and lastly the Crosscutting Concepts (CCC) which allow students to “apply scientific concepts to other areas” (King 2017). Throughout the Inquiry Cycles through the use of the DCIs of natural selection, cellular respiration and ecology students will engage with the CCCs of cause and effect and structure and function and the SEPs of analyzing and interpreting data and engaging with an argument based on evidence to create their evidence based explanation in the form of a CER.

To ensure student success with the integration of the Next Generation Science Standards in combination as well as success in creating this evidence based explanation, it is imperative that teachers utilize an anchoring phenomenon as the NGSS standards expect students to be able to explain the role of science concepts in phenomena. Furthermore, when addressing a diverse class of students it is crucial that "phenomena and problems should be compelling to all students, especially those students who do not see science and engineering as relevant to their lives or future careers" (Lee & Grapin 2022). To ensure that the anchoring phenomenon remains at the forefront of science instruction, lessons should be constructed "around specific questions about aspects of the phenomenon or problem" (Lee & Grapin 2022). By doing so, teachers create an essential or driving question for each DCI or unit that students will answer through their knowledge of science concepts and procedures in the form of their evidence based explanation. Therefore this inquiry will determine how the implementation of compelling culturally rich anchoring phenomenon affects students ability to engage in the SEPs of analyzing and interpreting data as well as the quality of evidence based explanations written by students.

Methodology

Teacher Inquiry

The goal of teacher inquiry, or "teacher research" is to "explore and extend teacher knowledge" as a way to better serve students in the classroom as teachers "take a close, critical look at their teaching and the academic and social development of their students" (Clark & Erickson 2003). This personal practice of continued learning through research is prompted by wonderings regarding the classroom structure, classroom community and/or intended learning outcomes, and is followed by cycles of planning, implementation, data collection, reflection, and interpretation. Through these cycles teachers undergo an “analysis of one’s own practices” intended to supplement “teacher knowledge” or dynamic nature of teacher learning and inquiry as an ongoing process (Clark & Erickson 2003). Through the enterprise of teacher knowing teachers analyze their teaching practices through a more detailed perspective to ultimately establish stronger pedagogical approaches with the purpose of positively impacting student learning outcomes, performance and the classroom culture and community.

Professional Learning Community

In order to appropriately address the dilemma of practice a professional learning community (PLC) will be utilized in conjunction with the process of teacher inquiry, as “progress depends on teachers’ individual and collective capacity” to analyze instruction and student learning (Stoll et al 2006). The term PLC can be applied to any group of educators working toward a common goal, which in the case of this inquiry stands as resolving the proposed dilemma of practice. When used effectively, the PLC has the potential to allow teachers to analyze “patterns in their own instruction and the resulting effects on student learning” thus helping one another to find solutions to their dilemmas of practice (Ippolito 2013).

Interventions

Academic Learning Outcome

The academic learning outcome that is imperative for student success in the science classroom is the ability to create an evidence based explanation based on an observable phenomenon. Thus, the main instruction strategy that will be implemented is the integration of culturally relevant anchoring phenomenon as the observable event that students use to observe the other otherwise unobservable scientific processes. By implementing these strategies students will see their cultures and communities reflected in the curriculum and will hopefully be more encouraged and motivated to engage with and participate in the curriculum. This implementation of culturally relevant anchoring phenomenon will allow students to engage in deeper meaning making of the curriculum as it Bang et al (2013) states "culture mediates relationships with, conceptions of, and innovations in technology and technologically related disciplines" Including the science discipline and that "recognizing these relationships will inform the subsequent implications for learning environments" (Bang et al 2013).

Classroom Culture

Furthermore, as students' lived experiences, histories, cultures and identities are personal to each student it is imperative that students feel safe and comfortable sharing their stories. Thus, the classroom culture that needs to be established for successful implementation on culture relevant anchoring phenomena is one that is inclusive, safe, and collaborative. This aspect of collaboration is extremely important as a collaborative environment allows students the "opportunities to make contributions to one's community and develop a sense of mattering" in response to the culturally relevant anchoring phenomenon (Eccles et al 2002).

Data Collection

Table 1

Data Collection Strategies

ANTICIPATED TIMELINE FOR ACTION PLAN			
Inquiry Cycle + (Data collection strategy to be used during the Inquiry Cycle)	Information that will help me answer my question (How will I promote student learning? How will I know that the intervention is effective?	Instructional Interventions/ Strategies	Evidence/Data to be Collected– (Plan for four types of data/collect each type of evidence multiple times)
Pre-Inquiry Cycle (S) Inquiry Cycle 1 (FG/V) Inquiry Cycle 2 (FG/V/S) Inquiry Cycle 3 (FG/V) Post-Inquiry Cycle (FG/V/S)	How do I implement culturally relevant anchoring phenomenons?	1. Find student interests and uncover lived experiences and histories 2. Align phenomenon with student experiences	Survey (S) Focus Group (FG)
	What culturally relevant phenomenon will I use?	1. Environmental impacts 2. Human impact	N/A
Pre-Inquiry Cycle (SW/FG/V/S) Inquiry Cycle 1 (SW/FG/V) Inquiry Cycle 2 (SW/FG/V/S) Inquiry Cycle 3 (SW/FG/V)	How do I know students are analyzing and interpreting data?	1. Implementation of data organization strategies (ie graphic organizers) 2. Implementation of CER	Student work (SW) Focus group (FG) Survey (S) Researcher Journal (RJ)

Post-Inquiry Cycle(SW/FG/V/S)		3. Implementation of real and relevant data sources (ie government data websites)	
Pre-Inquiry Cycle (SW/FG/V/S) Inquiry Cycle 1 (SW/FG/V) Inquiry Cycle 2 (SW/FG/V/S) Inquiry Cycle 3 (SW/FG/V) Post-Inquiry Cycle(SW/FG/V/S)	How do I know student explanations are evidence based ?	1. Implementing summary table 2. Implementing idea and answer checklists	Student work (SW) Focus group (FG) Survey (S) Researcher Journal (RJ)
Pre-Inquiry Cycle (S) Inquiry Cycle 1 (RJ) Inquiry Cycle 2 (RJ) Inquiry Cycle 3 (RJ) Post-Inquiry Cycle (S)	How do I create a collaborative safe classroom?	1. Using accountable talk 2. Setting classroom norms 3. Incorporating inclusion activity	Survey (S) Researcher Journal (RJ)

Survey

The survey that will be given to students consists of 11 Likert scale questions/;earning statements as well as two open ended questions(see Appendix A). The Likert scale questions/ learning statements address student beliefs regarding the relevancy of current biology curriculum as well as their perceived notions about the safety of their classroom environment and opportunities to collaborate with one another. Here student attitudes will be collected and will then be used to determine students' self efficacy and motivation. The two-open ended questions address students' attitudes towards the use of anchoring phenomenon, as well as students' thoughts about collaboration and how each of the two benefit or hinder students ability to participate in class and make sense of information. The information collected from the survey will be helpful as it will provide data from the student perspective. This survey will be given to students at two specific time periods over the PLC cycles, they will be given the survey before the implementation of interventions to assess students baseline feelings and attitudes, and Post Inquiry to collect students final thoughts.

Student Work

The student work that will be collected are students' evidence based explanations of implemented anchoring phenomenon in the form of a CERs or written paragraphs/oral presentations composed of a claim followed by evidence and reasoning that justifies how the evidence supports the claim. Additionally all work that supports students ability to create a CER including graphic organizers and summary tables used to help students observe patterns or inconsistencies in data and connect observations to implementing anchoring phenomenon. Collection of this type of work will help to inform of what observations and rationalizations students are making from different activities and labs. Furthermore, collection and analysis of student CERs will inform of students' capabilities in the creation of evidence based explanations.

Student CERs from the pre-Inquiry Cycle will be collected to serve as a baseline for ability and motivation to write an evidence based explanation. Additional CERs and/or graphic organizers and summary tables will be collected and analyzed during each phase of the Inquiry Cycle to track how the implementation of culturally relevant anchoring phenomenon motivates and improves on students ability to write an evidence based explanation of an observable phenomenon.

Rubric

The rubric that is being used to analyze students ability to create an evidence based explanation has been adapted from Kang et al. 2014(see Appendix F). The four criteria being looked at are:

1. The framing of explanation describing the link between the observable implemented phenomenon and unobservable scientific processes
2. The role of evidence in the form of patterns and inconsistencies found in data or observations from labs and activities
3. The depth of the explanation describing the “what”, “how” or “why” of the anchoring phenomenon
4. The overall coherence in logic and reasoning of the explanation

These criteria were chosen as they expand over all the necessary components of an evidence based explanation including students use of appropriate evidence and reasoning that is coherent with both the anchoring phenomenon as well as the scientific process and procedures.

Each of these four criteria has three ratings for the scale for performance level, developing, in which students students are in the beginning stages of forming and evidence based explanation making minor connections between phenomenon and scientific ideas, proficient in which students are able to make causal connections and skilled in which students are able to make and explain causal connections between phenomenon and scientific ideas.

Researcher Journal

A researcher journal will be used to collect data of observations for the multiple implementations that will take place. As integrations including the culturally relevant phenomenon that will be implemented, strategies to support students ability to create evidence based explanations (ie graphic organizers and summary tables) as well as integration of inclusion activities to promote a collaborative environment take place, observations made of students motivations, participation and ability to engage with one another and the task of creating an evidence based explanation will be recorded in the Researcher Journal. Additionally, when and how these interventions will also be noted. This is an effective data collection strategy as it allows for the focused observation of student response to interventions. The Researcher Journal will be used throughout the PLC cycle from pre-inquiry observations to Post Inquiry observations.

Focus Group

A focus group will also be used to determine the efficacy of the implementation strategies. As the main intervention will be the integration of culturally relevant anchoring phenomenon, a focus group comprising of several students from different cultural backgrounds will be looked at to see how self efficacy and motivation to write evidence based explanations as well as the quality of the evidence based explanations in students improves and/or changes in response to the intervention strategy. Since the classroom culture needed for successful integration of culturally relevant anchoring phenomena is a safe and collaborative space, the focus group will also be looked at to see how the collaboration between students in the focus group changes in response to the implementation strategies. Observations of the focus groups will take place consistently over the course of all PLC cycles.

Implementation of the Inquiry Cycles

ENACTED TIMELINE FOR INQUIRY			
Date	Interventions/ Strategies	Academic Learning Outcome or Classroom Culture the Intervention is Nested In	Data Collection Tool Used to Capture Evidence of Learning
Pre-Inquiry Cycle			
3/6/2023	N/A	Administered pre-Inquiry Cycle survey to students to gather students' ideas relating to anchoring phenomenon and the importance and application of science concepts learned in class.	Survey
1/9/23	Accountable talk	Collaborative environment	N/A
1/9/23	Group assignments (Jigsaw, station rotations, inclusion activities)	Collaborative environment	N/A
2/27/23	N/A	Evidence based explanation (CER)	Analysis of student work
Inquiry Cycle 1			
3/6/2023	Implemented more organized/formulaic strategy to write an explanation (CER)	Evidence based explanation (CER)	Researcher Journal Analysis of student work Rubric
3/6/2023	Implement anchoring phenomenon that highlights a new and diverse community	Self efficacy/motivation for CER creation	Researcher Journal Focus group

3/6/2023	Implement group structure for writing a CER	Collaborative environment	Researcher Journal Analysis of student work Rubric
3/6/2023	Summary Table	Analyzing and interpreting data (CER)	Analysis of student work Researcher journal Focus Group
Inquiry Cycle 2			
4/12/23	Increasing student agency in anchoring phenomenon that also connects to students interests	Self efficacy/motivation for CER creation	Analysis of student work Researcher journal Focus Group
4/12/23	Summary Table	Analyzing and interpreting data (CER)	Analysis of student work
4/28/23	Explanation and idea checklist	Evidence based explanation (CER)	Analysis of student work
4/28/23	CER Graphic Organizer	Evidence based explanation (CER)	Analysis of student work Researcher journal Focus Group
Inquiry Cycle 3			
5/8/23	Implementing anchoring phenomenon that allows for increased student agency	Self efficacy/motivation for CER creation	Analysis of student work Researcher journal Focus Group
5/10/23	Graphic Organizers	Evidence based explanation (CER)	Analysis of student work Researcher journal Focus Group
5/16/23	Explanation and idea checklist	Evidence based explanation (CER)	Analysis of student work
5/16/23	Highlighting CER	Evidence based explanation (CER)	Analysis of student work
5/18/23	Gallery Walk	Collaborative environment	Analysis of student work

			Researcher journal Focus Group
		Post-Inquiry Cycleamaz	
5/25/23	N/A	Administered post-Inquiry Cycle survey to students to gather students' ideas relating to anchoring phenomenon and the importance and application of science concepts learned in class.	Survey

Pre-Inquiry Cycle

Initial Data Collection Strategies.

Setting Up the Classroom Culture for Inquiry Cycles.

Prior to Inquiry Cycles in which the implementation of culturally relevant anchoring phenomenon was investigated, there was no greater observable phenomenon in which students could refer to while investigating scientific principles and processes. In addition while students often worked together on assignments, the work was not necessarily collaborative as students were not assigned clear and defined roles during the work, and work was intended to be alone but adapted to be done with partners in attempt to engage students, that is, work was not created with the purpose of creating a collaborative and safe environment at the forefront. In order to prepare students to engage with other in more meaningful ways, through collaborative assignments, accountable talk structures were introduced as well as group assignments and activities such a jigsaws, and station rotations, and inclusion activities that encouraged true collaboration as students build ideas off of one another and learned more about each other's lives and life histories.

In regards to culturally relevant science, prior to interventions proposed in Inquiry Cycle 1, there was very little connection between students' interests and life histories and the science curriculum. Science was taught primarily through direct instructions with activities with limited opportunities for authentic connection to the curriculum. Furthermore, in regards to evidence based explanations, opportunities to explain scientific processes and principles were not embedded and contextualized in events or observable phenomena that connected to students' interests or life histories. As explanations were found mainly in activities that supported the direct instruction of science curriculum, not the anchoring event in which students could connect to processes and principles found in science.

Because anchoring phenomenon was absent from instruction during the pre-Inquiry Cycle, student work that was collected consisted of explanations from observable processes in individual labs and activities as opposed to a greater observable event and essential questions for the entire unit. Furthermore, with the absence of an essential question for the unit that encourages students to explain the focal phenomena, the emphasis on the analysis and interpretation of data to be used as evidence was also minimal leading to student's focusing on what science concepts are and not how they occur. Despite this, work collected from the pre-Inquiry Cycle still remained valuable as it provided insight into where students were facing challenges in creating evidence-based explanations and highlighted that while students understand science concepts, they struggle with understanding how the role of interpreting data serves as evidence for why an observable event takes place.

Inquiry Cycle 1

Analysis of Student Work.

As aforementioned, work collected from the pre-Inquiry Cycle consisted of explanations taken from individual labs and activities. The specific piece of student work that was analyzed by the PLC was an explanation based on a virtual fly lab in which students mated flies and compared the expected outcomes of a cross obtained from a punnett square with the observed results of their cross. Here students were prompted to state whether or not their observed results matched their expected outcomes and explain their observations. Student work was then graded against a three point rubric consisting of developing, proficient and skilled (Appendix F). 71 samples of student work were analyzed by the PLC group and of these 71 samples, it was seen that 88% (63 out of the 71 samples) of the class had a performance level of developing when grading against the three point rubric and and the remaining 12% (8 out of the 71 samples) of the class fell under the proficient performance level of the proficient while there were no student work samples at the skilled performance level.

To analyze the work, members of the PLC group first established an ideal response based on the three point rubric. Based on this ideal response, student responses were graded against the three point rubric to determine baseline levels of student abilities to create an evidence based explanation.

Intervention Strategy.

The only intervention strategy utilized in the pre-Inquiry Cycle was the pre-survey, as well as the collection of student work. No additional interventions were implemented prior to

Inquiry Cycle 1 therefore, students were unfamiliar with the task of creating a well rounded evidence based explanation consisting of a claim, evidence and reasoning prior to the three Inquiry Cycles. Therefore, the student work from the pre-Inquiry Cycle will serve as a baseline to track student growth in their understanding of creating an evidence based explanation.

Based on this baseline data, it can be noted that a majority of students' performance level stood in the range of developing and therefore student explanations were not supported by evidence, and did not establish a link between the observable phenomenon and the unobservable concepts. For this reason, it would be beneficial to implement a more responsive anchoring phenomenon, such a culturally relevant anchoring phenomenon, in which students might be more interested in investigating. This may help to support students in establishing a causal link between the observable phenomenon and the unobservable scientific processes and principles as students may be more receptive to the observable phenomena and therefore more interested in explaining the scientific concepts resulting in the observations of the phenomenon.

Furthermore, because student explanations were not supported by evidence, it could be indicative that students may be having challenges analyzing and interpreting data to use as evidence and therefore another intervention strategy that will be implemented to support students in their use of evidence supporting their explanation is a graphic organizer called a summary table. Here the summary table will allow students to state observations from patterns and data and apply their theories for those observations to the anchoring phenomenon/observable event, as the components of the summary table includes the name of the activity, the patterns and data observed, the underlying science concepts and the connection to the anchoring phenomenon, thus putting greater emphasis on the patterns and observations seen in the data. Additionally, because students were facing challenges in creating a well rounded evidence based explanation, they will be introduced to the CER or the claim, evidence, and reasoning formula for creating a coherent explanation.

Classroom Instruction.

The lesson sequence that was taught in Inquiry Cycle 1 consisted of introduction to the anchoring phenomenon, the Bajau people: an indigenous community with unique traits suitable for their environment, explicit instruction on evolution by natural selection, several supporting labs and activities, and a final culminating activity where students formed groups of 3-4 and created a group CER answering the essential question, “How and why do the Bajau People have adaptations that are unique to communities like ours?”(Appendix D).

The intervention of the culturally relevant anchoring phenomenon was completed through the introduction of the Bajau people in the first lesson of the sequence and was carried out through the entire lesson sequence up to the final culminating activity of the group CER. Throughout the lesson sequences, the anchoring phenomenon and essential question allowed students the opportunity to think about and expand on their ideas of why traits are kept and/or lost in certain communities and how the environment influences the loss or maintenance of these traits. Opportunities for reflection on students' traits and how they are unique and differ from the traits held by the Bajau were also afforded to students throughout lesson sequences.

Additionally as students completed the supporting labs and activities in their groups, students filled out their summary tables to practice analyzing and interpreting data to eventually use as evidence for their CERs. Students completed this task in groups immediately after completion of each activity, to be able to use when writing their evidence based explanation in the form of a CER. A lesson on how to write a CER was also taught to students to introduce them to the components of the CER, including how to write a claim (answer question), where to find evidence and what constitutes as evidence (data from labs and activities), as well ad where to find the science concepts to use in their reasoning(notes on science concepts). Furthermore, because the summary table and analysis of data was completed in lab groups, the completion of the CER was also completed in lab groups to allow students to support one another through completion of their first CER.

Data Collection Strategies.

The strategies used to collect data throughout Inquiry Cycle 1 were the researcher journal in which observations were made throughout the lesson sequence regarding student attitudes towards the anchoring phenomenon, as well as student progress and motivation for completing their summary tables and CER throughout the lesson sequence. In addition to the researcher journal, a focus group of students from various cultural backgrounds will be utilized to determine how the anchoring phenomenon connects with students from different cultural communities. For this question regarding student efficacy and thoughts on the anchoring phenomenon were created prior to implementation of the anchoring phenomenon. Students were then called in during group work time independent of one another to answer these questions. Lastly student work in the form of the summary table graphic organizer and the CERs were collected to be analyzed with group members of the PLC.

Inquiry Cycle 2

Analysis of Student Work.

Upon completing the first natural selection CER in Inquiry Cycle 1, students' explanations were graded against the three point rubric. Here both students' summary tables and group CERs were analyzed with the help of the PLC. The summary tables were analyzed to establish their effectiveness in supporting students in constructing their evidence based explanations. Here it was determined that because students used these summary tables as the basis for their explanations, the summary tables were effective. Because students' worked in groups, there were 18 samples of student work to be graded. Of these 18 samples students were graded under four domains, the framing of explanation, the role of evidence, the depth of explanation and the overall coherence to obtain their final standing of either developing, proficient or skilled. With the help of the PLC group the claim was determined to be the answer to the question, the evidence was determined to be patterns or observations found from data and the reasoning was to address the science concepts learned about in class. Using this criteria it was found that 11 out of the 18 samples or 61% of the class remained at the developing skill level, four out of 18 student groups or 22% the class stood at the proficient skill level and the remaining three samples or the remaining 16% of the class had improved to stand at the skilled skill level. Through this analysis it could be concluded that while most student groups still grappled with using evidence in the form of patterns and observations from data, students were able to assess which science concepts were appropriate to answer the question resulting in textbook-like explanations as opposed to establishing a causal connection between the evidence and claim.

Intervention Strategy.

The main interventions used throughout Inquiry Cycle 1 was the implementation of a culturally relevant anchoring phenomenon that highlighted diversity through the introduction of the Bajau community, as well as the summary table graphic organizer. As this was students first introduction to phenomenon based learning and the formation of a CER to explain the phenomenon, the summary table and group work structure were put in place to act as scaffolds to further support students. The phenomenon chosen was used to appeal to students, however it was seen that not all students could relate to the topic of indigenous communities. While many students found the topic fascinating at first, their interest slowly faded as students had trouble connecting with the focal phenomena throughout the entirety of the unit. This resulted in students' motivation to explain the event to decrease throughout the unit resulting in the weak connection between the scientific processes and principles relating to the phenomena.

To address this discrepancy, the focal phenomenon used in Inquiry Cycle 2 will aim to relate to all students' personal interests and communities. Students will be given a greater sense of agency in choosing their own phenomenon to explain. Additionally, since this phenomenon will be more personal to students, students will create their CERs independently, though partner talk structures will still be used throughout the unit to develop the safe and collaborative classroom norms.

Additionally, as the summary table was implemented to support students in their competency of analyzing and interpreting data, students still faced challenges in incorporating these patterns of data and observations into their final explanations. As much focus was placed on the observations rather than the trends seen in the data, the summary tables moving forward will place a heavier emphasis on trends found in data. Furthermore, another type of graphic organizer will be introduced to aid students in creating a coherent CER. Through the use of a graphic organizer, students will be able to separate their claim from their supporting evidence, and will therefore be able to focus more on their use of evidence in the context of creating an evidence based explanation.

Classroom Instruction.

The focus of the unit in Inquiry Cycle 2 was the process of cellular respiration. The unit opened with students speaking to each other about their own personal hobbies and extracurricular activities they participate in. Students were given the opportunity to share with each other and the whole class about these activities and why they participate in them, and who they share these interests with. Students were then introduced to the focal phenomenon of the unit and the essential question of the unit (Appendix D). By framing the focal phenomenon around students' choice of athletes, including themselves and their friends, students were able to connect with each other and to their personal interests throughout the entirety of the unit, as well as see their own personal identity of an athlete reflected in the science classroom. During this introduction students were shown a collage of both male and female athletes, including transgender athletes. When asked to discuss who their favorite athlete was with a partner, conversations about the pay gap between male and female athletes were overheard as well as conversations about whether or not athletes that have undergone transitions should be allowed in professional spaces. While unexpected, this led to an important class discussion where students were able to voice their opinions on pressing social issues and challenges.

Students were then taught about the process of cellular respiration through direct instruction and a variety of activities such as the breathing rate lab and the muscle fatigue lab. The data collected from these labs was then input in the summary table where students could make sense of the data through science concepts and apply the science concepts to the essential question that asked what type of food source as well as what type of exercise is best to maintain their chosen athletes (which could be themselves or a friend), athletic abilities.

When it was time for students to create their CERs, students were introduced to the CER graphic organizer. Here all the components of the CER were offered with sentence frames to help students ensure that their explanations had a clear claim, evidence and reasoning. Here, students also had access to their summary table table graphic organizers where they could pick one piece of data from the summary table to use as evidence in the CER graphic organizer. Furthermore, when writing their CERS students had access to an ideas and answer checklist. The ideas and answer checklist served as a means to keep students accountable for ensuring their explanation, answered the question in the form of a claim, explained their claim using evidence in the form of data from an activity, and explained the process of cellular respiration in their reasoning. Furthermore, it served to ensure that students were continuing to use academic language and content specific vocabulary throughout their explanations.

Data Collection Strategies.

The analysis of student work, the focus group and the researcher journal were the main sources of data collection strategies for Inquiry Cycle 2. The researcher journal was used to detail moments of student interest and participation with the focal phenomenon as well as how students were engaging in the process of analyzing and interpreting data through the use of the graphic organizer. Additionally the focus group of students from different cultural backgrounds were asked questions about how the focal phenomenon related to them and how it affected their interest in cellular respiration as well as how student attitudes toward working alone versus working in groups. Finally the student work that was collected consisted of the CERs written along with the summary table and the CER graphic organizer used to support students in writing their CERs.

Inquiry Cycle 3

Analysis of Student Work.

The work that was analyzed with the help of the PLC group was the CER written by students answering the Inquiry Cycle 2 unit essential question of what the best food source and type of exercise was best for their chosen athletes. This was completed with the help of the PLC group by first examining the claim and the evidence used to support the claim to score the framing of the explanation and the role of evidence. The reasoning was then closely read to further determine the depth of the explanation as well as the overall coherence. When grading these against the three point rubric of developing, proficient and skilled in each of the categories there was heavy emphasis placed on whether or not students had referenced data from either of the two lab activities performed in class. After grading all 63 samples of student work (8 students absent and/or missing work), it could be found that 15 out of the 63 samples or 23% of student responses remained at the developing skill level, while a majority of the students 33 out of the 63 staples or 52% of the student responses stood at the proficient skill level and 15 out of the 63 samples or 23% of the students responses were seen at the skilled skill level. Here, it could be observed that there is an overall positive trend of students moving away from developing and toward becoming skilled in their capabilities to create and evidence based explanation. Furthermore, it could be seen that the students were improving in their use of data as evidence thus making improvements in the role of the evidence and framing of explanation categories.

Intervention Strategy.

The intervention strategies utilized throughout Inquiry Cycle 2 was the implementation of student choice for focal phenomenon as well as the introduction to a new graphic organizer used to help students organize their thoughts before creating a well rounded CER. It was evident that the option for students to choose to explain a focal phenomenon that resonated with them and their interests was helpful as students remained motivated and interested in the mundane process of cellular respiration throughout the entirety of the unit. Therefore, this option for student agency would remain in place throughout Inquiry Cycle 3 as well. Moreover, while the CER graphic organizer as well as the summary table graphic organizer were useful in allowing students to analyze and interpret data to use as evidence, student responses still lacked overall coherence. Therefore, in combination with the summary table graphic organizer, as well as the CER graphic organizer, students will be prompted to highlight each part of their completed CER to clear identify which part of their explanation is the claim, which part of their explanation is their evidence grounded in data and which part of their explanation provides a rationale for their claim and explains their evidence using science concepts.

Classroom Instruction.

The unit topic covered throughout Inquiry Cycle 3 was ecology intertwined with human impacts on the environment (Appendix D). To open the unit students first calculated their ecological footprint to understand the role they play in their environment. When completing this task, students had to take into consideration their socioeconomic status, as well as their lived experiences in the ways in which they and their loved ones interact with the environment. This task was followed by an whole class open discussion of why it is important to recognize how all human actions have repercussions on the environment. The following subsequent lessons in ecology were then interspersed with human impacts relating to individual lessons in an attempt to have class discussions surrounding the human impacts of climate change, overconsumption, habitat degradation and introduction of invasive species to communities. Each time a new human impact was introduced students were to explain how each of these impacts could influence an organism's population size in their summary tables. Upon learning and discussing the importance of these human impacts, students were prompted to choose one human impact to explore for their CER by connecting the human impact to a population of their choice to answer the essential question: how has the species population size been affected by an environmental challenge? To complete this task students worked in groups to research data about their chosen species population size and how it has been affected by the environmental challenge of their choosing.

When writing their CERS, students were given access to their summary tables, as well as provided with a fresh CER graphic organizer and answer and idea checklist. Before submitting their final CERs, groups were prompted to highlight each distinct part of their CER contrasting colors to ensure that all components of the CER were clear and evident. The unit culminated with a gallery walk of student CERs where students could engage with each other's writing to learn more about the different human impacts and environmental challenges to suggest solutions that individuals can take to reduce the impacts that humans have on their environments.

Data Collection Strategies.

The strategies used to collect data were the collection of student work in the form of the CER as well as the summary table graphic organizer and the CER graphic organizer used to support students in writing their final CERs. Additionally the researcher journal with observations regarding student interest in their chosen species as well as environmental challenges were also noted. Moreover, the manner in which students interpreted data found through online research was also noted in the researcher journal. Lastly, the focus group composed of a group of diverse students with differing life histories and experiences was asked questions regarding their interest in the focal phenomenon and how they can apply what they have learned through their research and the ecological footprint lab to other aspects of their lives.

Post-Inquiry Cycle

Final Analysis of Student Work.

The final work analyzed consisted of the CERs on human impacts collected from Inquiry Cycle 3 as well as the student responses of solutions taken from the gallery walk. As students once again created their CERs in groups, there were 18 student work samples collected. These work samples were once again graded against the three point rubric consisting of developing, proficient and skilled. Out of the 18 work samples, nine samples or 50% of the student CERs were at the proficient skill level while the remaining nine or 50% of the student CERs were at the skilled skill level. This further supports the students positive trends moving toward the skilled skill level as there were no students that remind at the developing skill level, therefore, it could be justified that students were improving in their abilities to use evidence found in data to provide a rationale for their claim, despite some students still have challenges establishing causal connections.

Final Data Collection Strategies.

The final set of data from Inquiry Cycle 3 consisted of the post-Inquiry Cycle survey which was administered following students gallery walks. The survey focuses on how students make sense of the science curriculum and how phenomenon based learning motivates students in using data to create an evidence based explanation. All of the student work samples from the Inquiry Cycles 1 through 3 were also analyzed for trends and differences and improvements throughout the units, more specifically how students engaged in the process of analyzing and interpreting data through the use of the summary table graphic organizer, as well as how students used science concepts to provide rationale through the use of the CER graphic organizer.

The researcher journal was also used to note observations regarding how students interacted with the anchoring phenomenon through their motivation and interest with the focal phenomenon of human impacts as well as how students' use of data changed when using labs and activities as evidence compared to researching data for evidence.

Finally the focus group of students from different backgrounds was asked questions regarding how the choice of human impact affected their interest in the subject in addition to how the gallery walk helped to connect them with both their peers and the subject matter. Questions relating to the overall Inquiry Cycle and the implementation of phenomenon based learning were also asked to gather students' thoughts on phenomena based learning compared to the more traditional approach.

Data Analysis and Interpretation

Survey Trends and Patterns

In this section, first inform the readers how many students took both the pre- and post-Inquiry Cycle surveys and how many incomplete data sets you had to discard. Remind the readers how many Likert scale questions you asked in the pre-Inquiry Cycle survey and whether you added or removed any questions in the post-Inquiry Cycle survey. Select the questions that you feel are most relevant to your inquiry and just write about those. Discuss what trends and patterns you see in the data and why you think the rating increased, decreased, or stayed the same. Highlight significant or unexpected findings and provide a rationale for why you think the results turned out that way. Refer the reader to Appendix B for the Survey Results.

There were a total of 64 students who took the Pre Inquiry Cycle survey and 66 students who took the PostInquiry Cycle survey. In order to have complete data sets of students who took both the Pre Inquiry Cycle survey and the PostInquiry Cycle survey, two data sets were removed from the Pre Inquiry Cycle survey and four data sets were removed from the PostInquiry Cycle survey in order to have 62 complete data sets. The survey that students completed consisted of three demographic questions, 11 likert scale questions/learning statements regarding students connection with the science curriculum, their ability to do science and their thoughts on the classroom environment in which they complete their learning of science, and finally two open ended questions in which students discuss how the implementation of anchoring phenomenon affected their ability to do science and once again their opinions on the classroom environment. There were no modifications made between the Pre Inquiry Cycle and PostInquiry Cycle surveys, that is, both surveys had the same questions and content.

In regards to students' connection with science, it can be seen that there is a slight trend towards students finding deeper connection and meaning with the science content proposed after the implementation of a culturally relevant curriculum through anchoring phenomenon that highlights the indigenous Bajau community to describe natural selection, anchoring phenomenon that connected to student interest in the form students' chosen athletes to describe cellular respiration, and anchoring phenomenon that relates to human impacts and the environment to describe ecology. When looking at the question/learning statement, "The topics we learn about in Biology are relevant to me", it can be seen that while more students "agree" with the statement before the Inquiry Cycle took place, a greater number of students "strongly agree" with the statement after the interventions were added. Additionally, while more students felt "neutral" about the statement, that is, they neither agreed or disagreed with the statement, PostInquiry Cycle compared to Pre Inquiry Cycle, there were a fewer number of students who "disagree" or "strongly disagree" with the statement PostInquiry Cycle (Appendix B). A similar pattern emerged with the question/learning statement "The topic we learn about in Biology are important me", where a fewer students "agree" despite greater number of students "strongly agree" with the statement after the Inquiry Cycle took place and more students felt "neutral" about the statement, while less students "disagree" or "strongly disagree" with the statement (Appendix B). A possible explanation for the appearance of this pattern between Pre and PostInquiry Cycles regarding the students' attitudes regarding their personal connection with science, is that intervention of culturally relevant phenomenon that aims to connect to students interests and life histories, only resonated with students that had an interest in science phenomenon prior to the Inquiry Cycle, therefore some students that had previously felt that they had "agre[ed]" with the statement, were positively affected in terms of their personal connection with science moving to the “strongly agree” rating after the interventions took place, while other students who may have found connections in the traditional method of teaching science concepts (without focal phenomenon) were distracted or discouraged by the shift towards phenomenon based learning moving towards the “neutral” ranking. Ultimately overall, it could be assumed that the class data did show a positive trend toward increasing engagement and interest with science despite fewer students agreeing and more students feeling neutral, as fewer students disagreed and/or strongly disagreed, meaning that a majority of students who displayed an extreme lack of connection in science topic prior to the Inquiry Cycle, found slight interest after the interventions took place. Furthermore, this assumption could be confirmed by the results to the question/learning statement “The topic were learn about in biology are interesting to me” as a greater number of students moved toward both “strongly agree” and “agree” and away from “netral”, “disagree” and “strongly disagree”(Appendix B), meaning that while students may have found the topic more interesting, their ability to connect the science concepts to their lives outside of an academic setting were not impacted as greatly overall.

While students personal interest with the topics presented in class had varying results, moving towards both “strongly agree” and “neutral”, students attitudes towards how the topics taught in biology impacted their community were evident as all there were a greater number of students who “strongly agree[ed” and “agree[ed]” with the question/learning statement “The topics we learn about in biology are important to community”, PostInquiry Cycle and a fewer students felt “neutral”, “disagree[ed]” or “strongly disagree[ed]”(Appendix B). This could due to the last unit on ecology in which students were prompted to make sense of different impacts humans exhibited on their environment and research different ways in which they could help mitigate these impacts at the personal, community and governmental levels, therefore, because of this, students knew that the this topic was relevant to their overall communities and earth as a whole despite not feeling a personal connection or interest with the topic.

When looking at questions based on student thoughts and feelings about their abilities to do science through analyzing and interpreting data to create an evidence based explanation, there is a general positive trend towards students increasing confidence levels. When looking at questions/learning statements "I am confident in my ability to create evidence based explanations by myself" as well as "I am confident in my ability to identify patterns in data and observations", there was a larger proportion of students who "agre[ed] with the statement after all three Inquiry Cycles took place. Additionally there were less students who "disagree[ed]" with the statement (Appendix B). This could be explained by student's increasing interest as aforementioned translating to increasing confidence in their abilities to perform science skills. Additionally, as students completed an evidence based explanation in the form of a CER with every Inquiry Cycle, students had repeated practice with analyzing and interpreting data, and evaluating that data to use as explanations in their CER, therefore, this repeated practice also positively affected students confidence in creating an evidence based explanation in the form of a CER. Furthermore, under the assumption that increasing interest in biology topics and confidence in science skills and writing abilities allows students to be more motivated to create an evidence based explanation in the form of a CER, it could be noted that students self efficacy in creating their evidence based explanations increased with their increasing interest in science and increasing confidence.

Lastly, students' confidence in science skills and procedures and interest in science topics could be attributed to students beginning to feel a greater sense of safety and collaboration in the classroom. Looking at students responses to the questions and learning statements to “I feel safe to express my thoughts and opinions during class discussions”, students felt positively as they moved toward the rating or “strongly agree” and “agree” and away from feeling “neutral” or feeling that they “disagree” or “strongly disagree” (Appendix B). In combination with students being introduced to more relevant anchoring phenomenon as well as the implementation of collaborative interventions such as group CER writing structures students felt more inclined to participate in group discussions as they had more opportunities to engage with their peers, lessening the fear or shame of sharing their ideas, as well as increasing their self-efficacy to participate as students now maintained a deeper connection to the curriculum. For example, in Inquiry Cycle 2, the anchoring phenomenon of exercise for athletes was utilized, here because students had previous connections with the phenomena students were able to bring in their previous knowledge into conversations with peers/group discussions.

Ultimately, when looking at all the Likert scale questions from the students’ Pre and Post Surveys, results would indicate that 1.) students felt more connected to the material at the individual and community levels, 2.) students felt more confident in their ability to carry out scientific skills and routines and 3.) students felt more comfortable sharing their thoughts and opinions during class. Together with these findings in mind, it could be postulated that students were more motivated and more engaged with the science curriculum with implementation of the inquiry interventions.

Thematic Analysis & Learning Statements

Theme 1: Humanizing Experiences.

Due to the nature of this inquiry standing as the implementation of a culturally relevant anchoring phenomenon, the curriculum aims to connect to students' cultures, interests and life histories, allowing for students to see their identities reflected in the curriculum; as the issue that this inquiry aimed to address what the disconnect between students lives and the science curriculum they interact with. During Inquiry Cycle 1, which highlighted the Bajau people, a focus group of students was asked how the implementation of the anchoring phenomena allowed them to see themselves, their cultures, and communities reflected in the curriculum to which a student responded “I think when we were talking about variation, how the Bajau people have big spleens and we have regular spleens... I think it explains why we're different and like we are all different for different reasons….but it's because of biology *[sic]*”(Appendix B). Here students' connection with the phenomenon is apparent as the student was able to use the science concepts uncovered through the implementation of the phenomenon to justify why each community, including their own community, possess differences when compared to other communities. Furthermore, the student is able to situate themselves within the context of the focal phenomenon despite the phenomenon lacking an explicit connection between students' cultures and communities and the Bajau indigenous community, thus establishing that students are capable of identifying with the curriculum.

Furthermore, as Inquiry Cycle 2 aimed to connect specifically to student interests, students were afforded the opportunity to have agency over the focal phenomenon investigated, to better establish rich connections with the focal phenomenon. Here students responded to this decision by claiming that the choice "made [the phenomenon] more personal to [the student]" making the science concepts "more interesting" and that the choice allowed them to "chose people [they] related to *[sic]*" when asked about the choice in a focus group survey (Appendix B). These statements confirm the idea that students possessing agency over what they investigated allowed the students to relate the content on a personal and cultural level.

Ultimately, these findings confirm that student engagement is positively correlated with the implementation of culturally relevant anchoring phenomenon. This positive correlation is not surprising as students are more likely to engage in topics that they relate to. When students are capable of finding deeper meaning with content, teachers can "promote energy and vitality" among students as a culturally responsive curriculum not only supports cultural values, "but also their psychological well-being" resulting in these humanizing experiences (Cholewa 2014).

Aside from students' ability to identify with the curriculum and establish agency over their own investigations, students also saw an increase in collaboration resulting in an overall positive impact on the classroom community. During Inquiry Cycle 3, in which students experienced their first galley walk, students responded to the walks by stating, "the gallery walk was cool because it allowed us to see what everyone else had researched, and we could see what we could all do to help the other endangered animals" (Appendix B). This statement exemplifies a positive impact to the classroom community as the student interactions that took place during the gallery walk not only allowed but encouraged students to make interpretations based off of their peers' works and extend those interpretations into their lives and communities beyond the classroom, confirming the idea that understanding and incorporating "youth culture" had the potential to transform learning for students as students (Ladson-Billings 2021).

Theme 2: Negotiation of Meaning Between Students and Content

Throughout the three inquiry cycles, the acquisition of deep sense making of knowledge occurred through students' relation with the anchoring phenomenon presented in the class. For example, when responding to the CER on cellular respiration, it was noted by the researcher that "students [were] using personal knowledge of athletes to find appropriate lab or activity to use as evidence for cellular respiration CER"(Appendix B). Throughout this task, students were asked to determine what type of exercise and food source would be the best for their chosen athlete. Because students needed to use their prior knowledge of the athletes to answer the essential question, students used this prior knowledge to evaluate which activity and data interpretation would be the best to provide evidence for their claim in their CER. For example, a sample of student work displays a student using their knowledge of Lance Armstrong to decide what type of exercise is best for Armstrong, which informs their decision of which lab activity would best suit their claim. Here the student states, "Becaused he was diagnosed with cancer he should stick to moderate intensity cardio. Since he has cancer he needs to be careful so that he does not go into lactic acid fermentation and get too sore. Evidence for this is the muscle fatigue lab. When I first started the muscle fatigue lab I was able to do 35 squeezes with the tennis ball, but after 2 minutes i could only do 19 squeezes. This was because my mitochondria started doing lactic acid fermentation which created less ATP, which is why Lance Armstrong should stay away from high intensity exercise. *[sic]*" (Appendix B). Throughout this explanation, the student uses their "household knowledge" of Lance Armstrong's bout with cancer to make the assumption that Lance Armstrong should "stick to moderate intensity cardio". Now that the student has made their claim, they have the responsibility to choose which activity and data provides the best evidence for this claim of “moderate intensity cardio”, requiring knowledge of the science concepts of both aerobic respiration and lactic acid fermentation. In this example, the student identifies a suitable source of evidence, the “muscle fatigue lab”, to justify their claim, based on their prior knowledge of Lance Armstrong’s life history. As the inquiry question revolved around students' ability to analyze and interpret data to create a well written CER, it is seen that intervention was indeed successful in terms of negotiation of meaning between the student and the content.

The example above illustrates how students tap into their funds of knowledge to make deeper connections allowing for more opportunities of critical thinking and sense making. This finding is not surprising as it is known that “students make sense of new information in relation to what they already know” (Heal and Goodwin 2023). In these inquiry cycles, students were provided with opportunities to connect information about topics they know and care about with new information regarding science concepts and topics deepening their understanding of these science concepts. Moreover, teachers' use of students' funds of knowledge and prior understandings can be transformed into knowledge in the context of science content and the curriculum (Genzuk 1999).

Throughout these inquiry cycles through the use of culturally relevant phenomena, students were given multiple opportunities to extend their sense making beyond the classroom context. In Inquiry Cycle 3, students participated in a gallery walk of student projects which included student CERs of human impacts on the environment as well as possible solutions of what humans could do to mitigate these impacts. When conducting a focus group interview with a student, the student was asked how they could apply what they learned from the gallery to their lives to which the student responded “I learned alot about how there is little things that we can do to help save the orangutans, but there's also a lot that we have the government do improve it even more *[sic]*” (Appendix B). Here the student acknowledges that there are multiple ways in which they can help restore the environment through personal tasks they can do as an individual but also on the governmental level, demonstrating that the student has applied what they have learned beyond just the classroom.

Furthermore, as all three inquiry cycles came to a close, the effectiveness of the anchoring phenomenon as a whole was addressed as students were asked, “How does using phenomenon help you make better sense of the material presented in class?” (Appendix A) both before and after the interventions took place. Prior to the inquiry students were confused and disinterested in the phenomenon making statements like “What is phenomenon??? *[sic]*” and “I dont know and I dont care *[sic]*”, however after Inquiry Cycle 3, student responses to the questions changed to “Phenomenons put what were learning in perspective. Instead of making lessons only fact based, it helps connect what we learned to the world..it helps me remember, like with the bajau people theyre something to remember which helps me remember what we are learning *[sic]*” and “Because it gives me an understanding and an example of what's going on, making it easier to understand and make statements about it” respectively (Appendix B). While the shift from confusion/disinterest to understanding was expected, it was surprising that most students who provided an example of a helpful phenomenon referred to the Bajau indigenous community from Inquiry Cycle 1 despite their engagement seemingly being higher with implementation of the anchoring phenomenon from Inquiry Cycle 2 and Inquiry Cycle 3. This could be interpreted with the idea that although student agency increased engagement, phenomena that highlighted diversity and culture were more effective in terms of student sense making. This aligns with the research as it is noted that phenomena rooted in students' cultures promote student learning in the classroom (Lee & Grapin 2022).

Theme 3: Equity and Access.

Phenomenon that is rooted in students' cultures and interests inherently requires students to divulge their community and cultural funds of knowledge. As aforementioned, tapping into these funds of knowledge is known to increase student sense-making, however it is also known to make education more accessible to all students, as all students report different funds of knowledge based on their prior experiences. When all students are given the opportunity to leverage these different funds of knowledge, the classroom itself becomes a more inclusive and equitable environment as all students are appreciated for what they bring into the classroom rather than just what knowledge they leave with.

Looking at the same sample of student work taken from Inquiry Cycle 2, the student introduced the topic of his investigation by stating, “Lace Armstrong is world renowned cyclist and has won the tour de france multiple times. Because he was diagnosed with cancer he should stick to moderate intensity cardio *[sic]*” (Appendix B). Here this student used their cultural funds of knowledge about Lance Armsrong to further engage with the task. Because it is known that without explicitly allowing students to relate the content “higher-performing students will end up getting more chances to think effortfully, while lower-performing students often recede into the background of the classroom”, therefore, encouraging all students to find deeper and more meaningful connections with content allows more students, including lower performing students or students with IEPs and 504 plans, supports the creation of more equitable classroom environment as there are less barriers to accessing curriculum (Heal & Goodwin 2023). This finding confirms that " phenomena and problems rooted in students' experiences and language promote both equity and science and engineering learning" (Lee & Grapin 2022).

Also important to take into consideration is the notion that all students and teachers have preconceived ideas of what "smart" looks like in an academic setting in the form of "settled expectations" (Bang et al 2013). Because of these "settled expectations", students may not feel as though they are capable of engaging with scientific practices such as analyzing and interpreting data or composing an evidence based explanation. Therefore, phenomena that pique students' interest, solicit students' funds of knowledge and increase students' self efficacy in engaging with these skills, produce a more equitable classroom by challenging these "settled expectations" as students are appreciated and rewarded with deeper sense making of science concepts.

Future Plan of Action

Teacher Agency

Recommendations for Pedagogical Changes.

In these Inquiry Cycles, the anchoring phenomenon chosen was created intentionally to relate to students' cultures, interests and life histories, and essential questions for anchoring phenomenon followed. While students did experience higher levels of engagement with the anchoring phenomenon of the Bajau indigenous community, students unsurprisingly had the greatest level of engagement when given the agency to choose their own topics to explain in their CERs, therefore, it is recommended that both students and teacher have agency over the anchoring phenomenon in which students investigate. By doing so, teachers are able to tap into students' personal and cultural funds of knowledge and are able to bridge this pre-existing knowledge with new science concepts. For example, during Inquiry Cycle 2, students were given the authority to choose what athlete they would investigate for the CER. Here, many students took into consideration their pre-existing knowledge of the sport and their knowledge of the athlete and connected that knowledge with new information gained in class which ultimately prompted sense-making.

Furthermore, giving students agency in their investigations allows students to make sense of the science concepts beyond the classroom, and teachers can maximize this impact by allowing students to share their CERs with their class and communities, whether that is explicitly through collaborative CERs, presentations or gallery walks or implicitly by displaying student CERs on walls for students to look at during their free time. When completing Inquiry Cycle 3, students made sense of their own impact on the environment through both the ecological footprint activity and through their environmental impacts CER, during the gallery walk of their CERs students were given greater opportunity to see their impacts on the environment resulting in the science concept having a greater relevance to themselves and their communities.

Recommendations for Policy Changes.

This inquiry project indicates a great need for policy change in the realm of education regarding culturally relevant pedagogy. For starters, while some schools have adopted the shift towards phenomenon based learning, many institutions have yet to adopt this practice. Moreover, it is imperative that as schools do adopt the practice of a focal phenomenon that the focal phenomenon not only be interesting to students, but connects to students life experiences, histories, cultures and lived experiences, which can only be done, if schools allow and encourage teacher agency in choosing what phenomenon is best for the context of their students requiring not only administrative approval for teacher agency but also administrative support as schools need to be supportive of teachers have choice and power over what anchoring phenomenon they decide to implement in their classrooms.

Recommendations for Future Research.

To improve this inquiry project, the chosen focal phenomena that related to students' lived experiences, life histories and interests could have been centered through the lens of social justice. In this inquiry project, there were many opportunities to engage in dialogue and discussion about social justice with the anchoring phenomenon chosen. For example indigenous rights and colonialism for Inquiry Cycle 1 where the Bajau people were the center of student investigation, sexism and the pay gap in professional sports in Inquiry Cycle 2 where athletes were the center of student investigation, and environmental justice in Inquiry Cycle 3, where students investigated human impacts on the environment. While there were moments where students did engage in similar types of conversations, most notably when the anchoring phenomenon were introduced, students did not have the opportunity to continue and dive deeper into these discussions as the social justice aspect of the anchoring phenomenon was not embedded within the curriculum due to time constraints and lack of support for social justice centered phenomenon from mentors.

For this reason, it would be beneficial to see future research being conducted on the intersection of cultural relevance and social justice in the science classroom to gauge how student self-efficacy and performance increases with the addition of the social justice perspective. While there is much research regarding the positive impact of culturally relevant and sustaining pedagogy, where teachers are encouraged to validate student identities, research focused on how teachers can take their curriculum one step further into positioning students as agents of change and transformation through the intersection of science and social justice initiatives is imperative.

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Appendix A: Survey Questions

Research Question:
How might the implementation of culturally relevant anchoring phenomenon encourage my 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment?

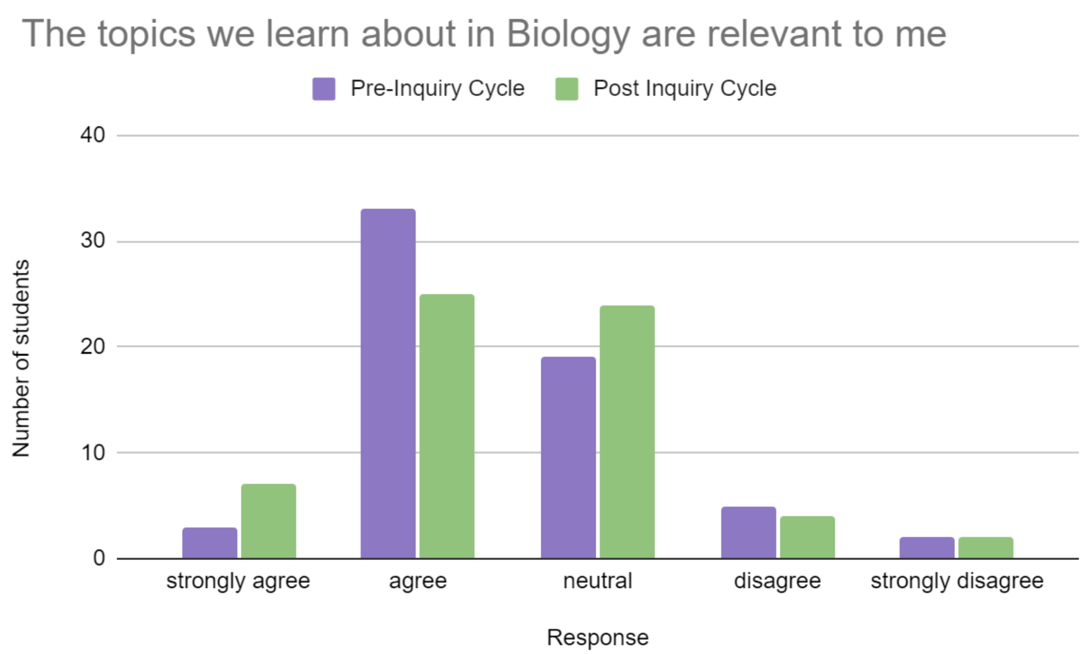
Demographic Questions
1. First Name
2. Last name
3. Period

Likert Scale Questions
4. The topics we learn about in Biology are relevant to me (Strongly disagree, disagree, neutral, agree, strongly agree)
5. The topics we learn about in Biology are important to me (Strongly disagree, disagree, neutral, agree, strongly agree)
6. The topics we learn about in Biology are important to my community (Strongly disagree, disagree, neutral, agree, strongly agree)
7. The topics we learn about in Biology interest me (Strongly disagree, disagree, neutral, agree, strongly agree)
8. I am confident in my ability to analyze and interpret scientific data (Strongly disagree, disagree, neutral, agree, strongly agree)
9. I am confident in my ability to identify patterns in data and observations (Strongly disagree, disagree, neutral, agree, strongly agree)
10. I am confident in my ability to create evidence based explanations by myself (ie. Complete My Thoughts Summary Table or CER of Phenomenon) (Strongly disagree, disagree, neutral, agree, strongly agree)
11. I feel safe to express my thoughts and opinions during class discussions (Strongly disagree, disagree, neutral, agree, strongly agree)
12. I prefer working with my peers (lab groups) than alone (Strongly disagree, disagree, neutral, agree, strongly agree)
13. I am given multiple opportunities to collaborate with my peers (Strongly disagree, disagree, neutral, agree, strongly agree)
14. I would like more opportunities to collaborate with my peers (Strongly disagree, disagree, neutral, agree, strongly agree)

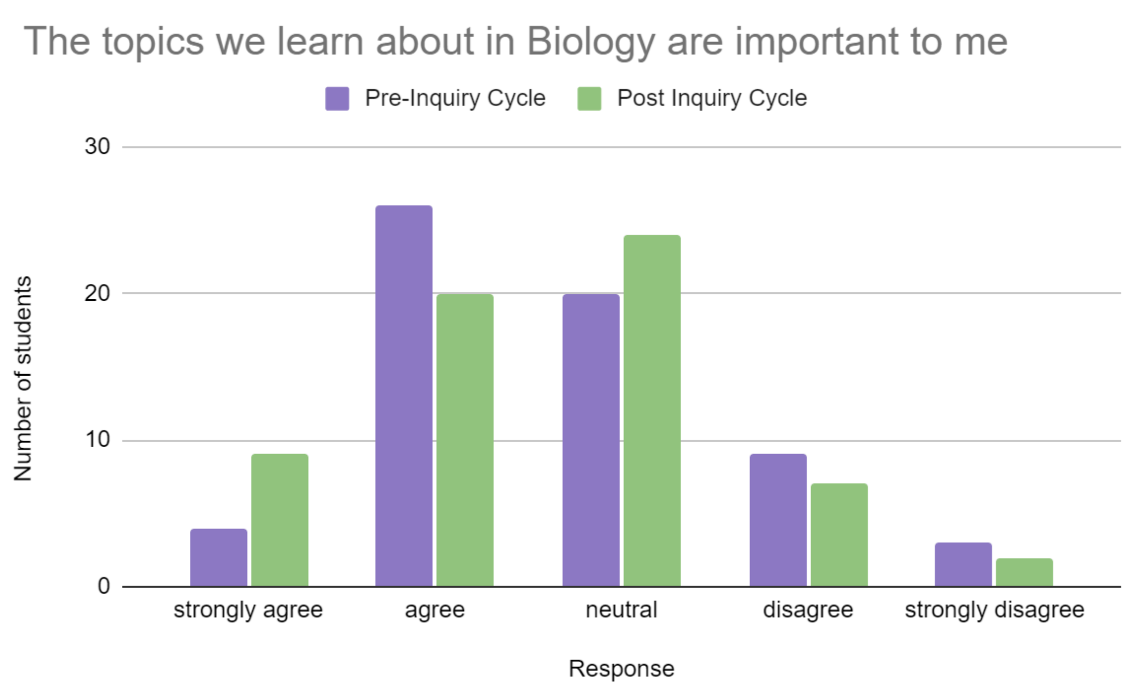
Open ended questions
15. How does using phenomenon help you make better sense of the material presented in class? (Note: if phenomenon makes you more confused explain why)
16. How does working with your lab groups help you write CERs? (Note: If your group does not help you explain why)

Appendix B: Survey Results

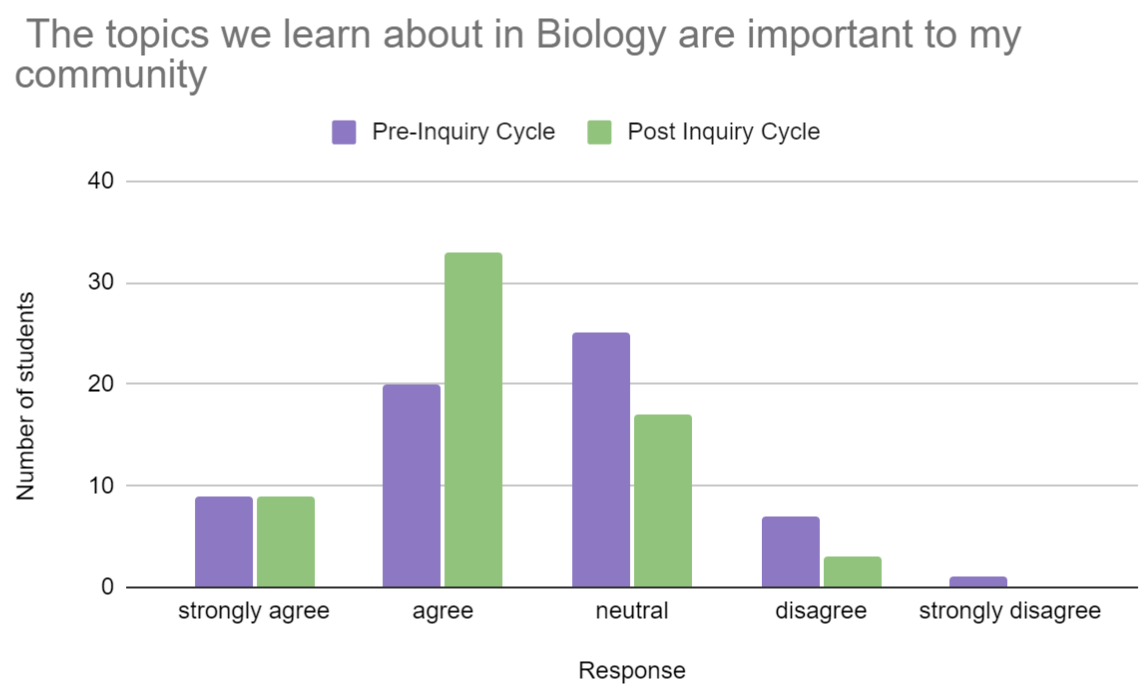
Graph 1: Pre and Post Survey results for Question 4



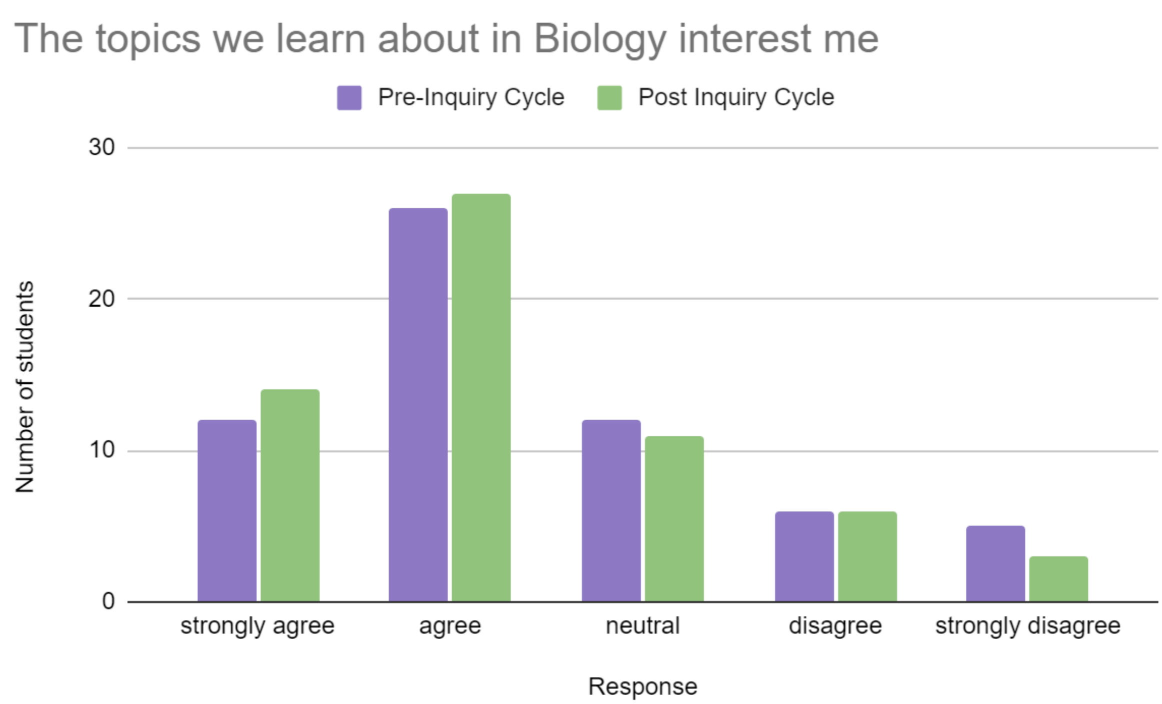
Graph 2: Pre and Post Survey results for Question 5



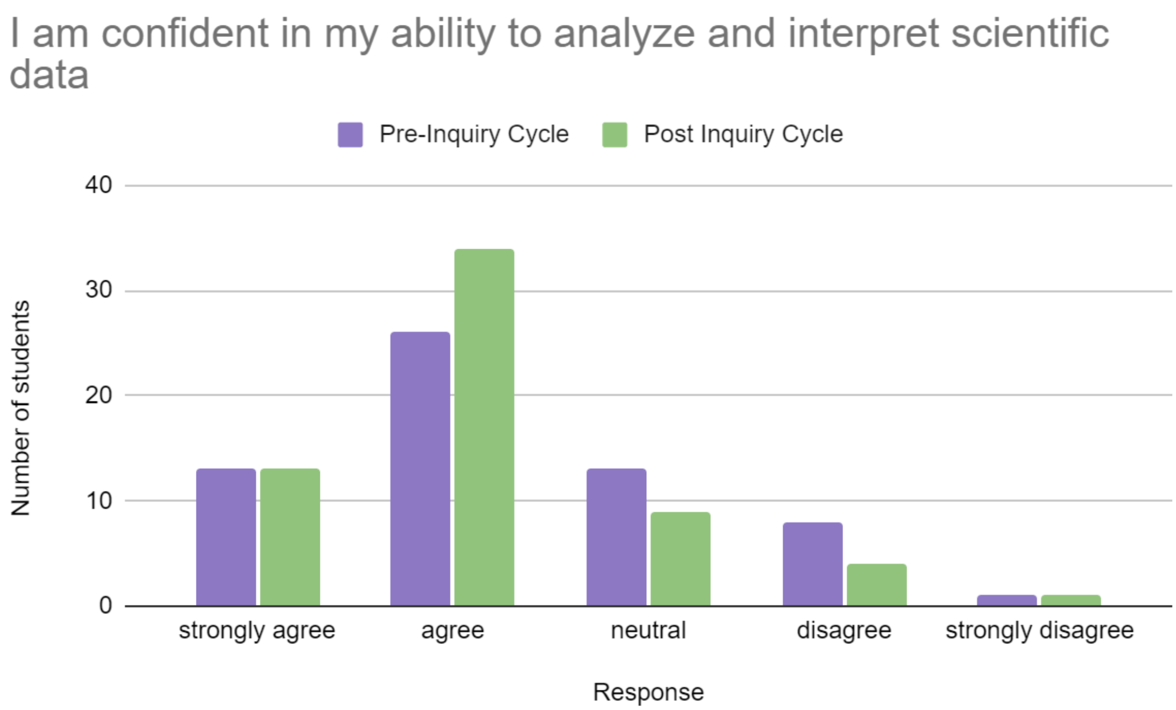
Graph 3: Pre and Post Survey results for Question 6



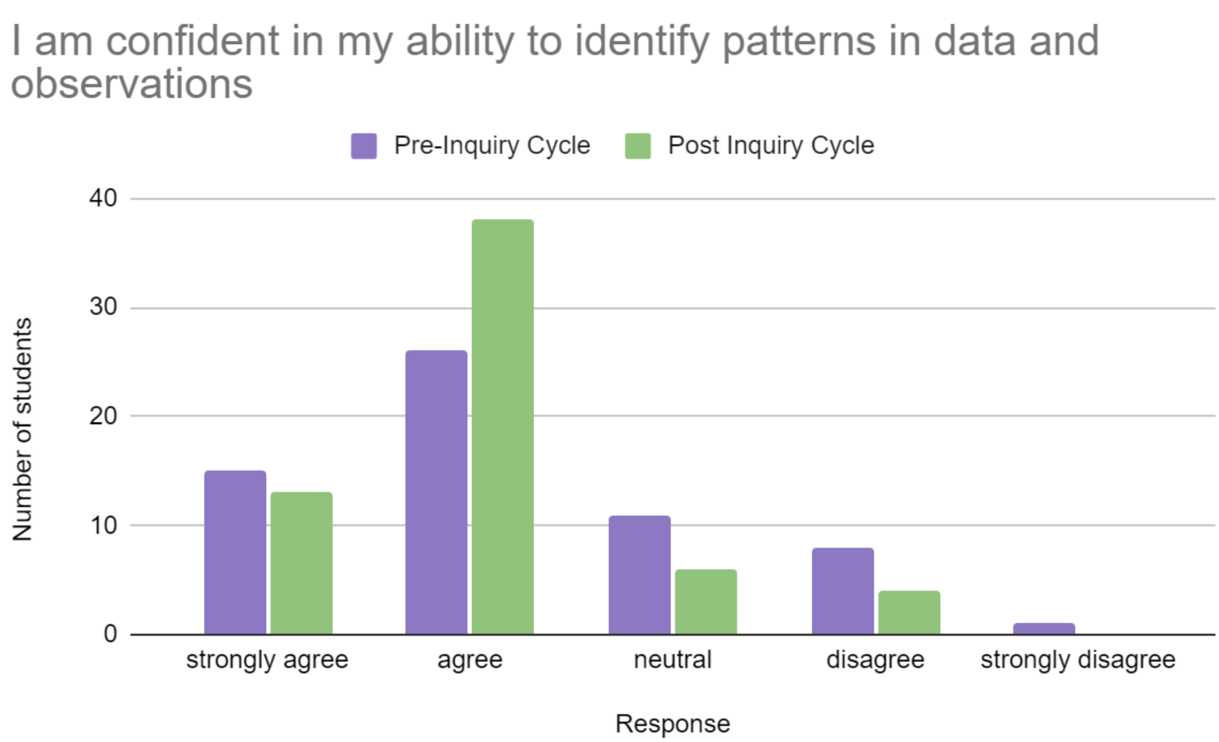
Graph 4: Pre and Post Survey results for Question 7



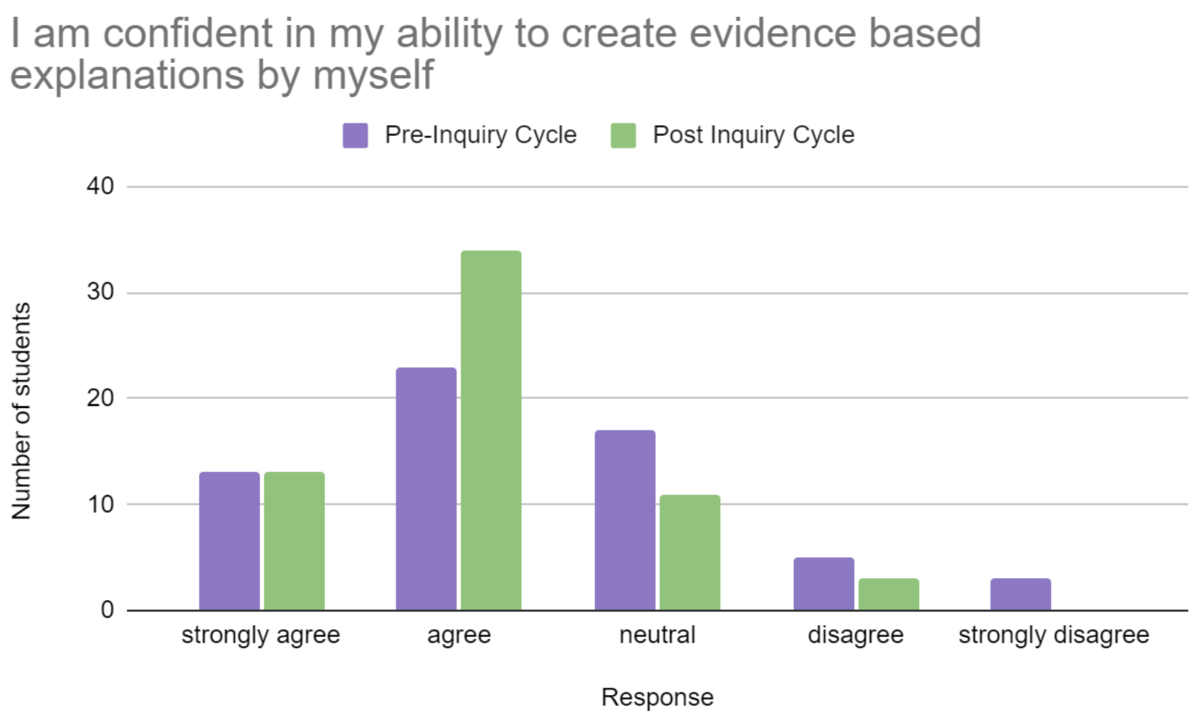
Graph 5: Pre and Post Survey results for Question 8



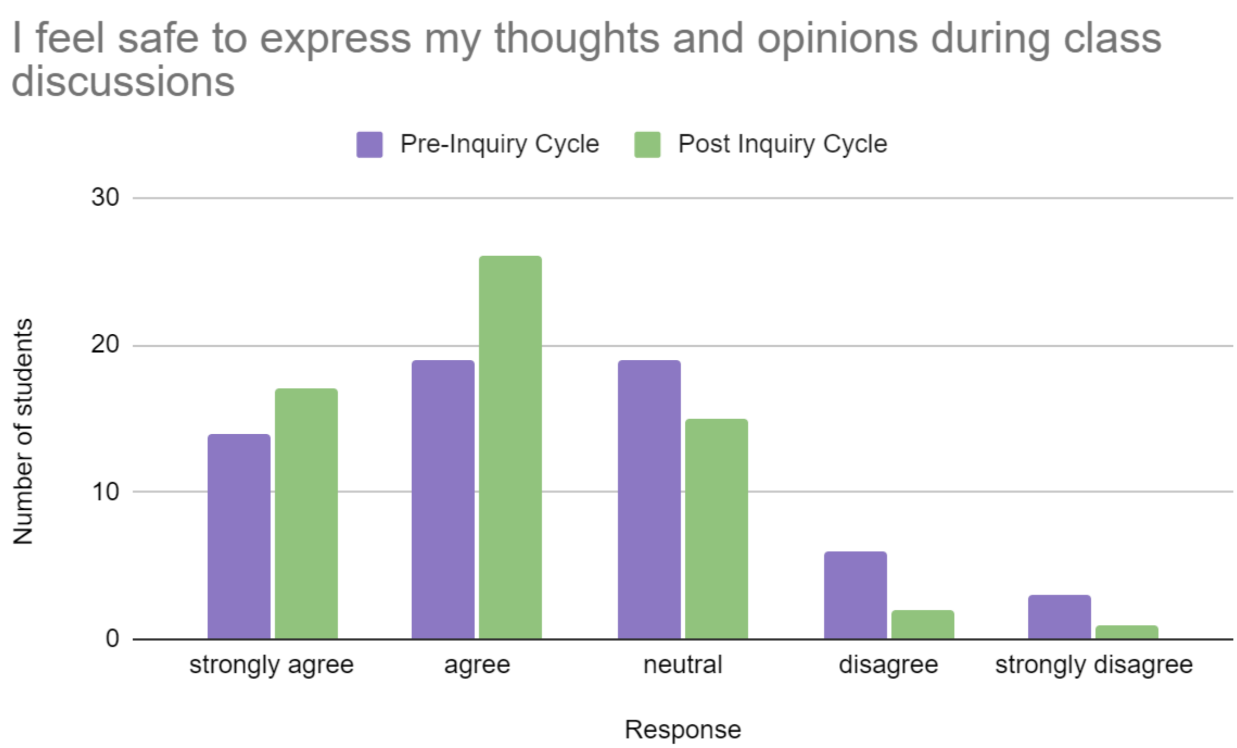
Graph 6: Pre and Post Survey results for Question 9



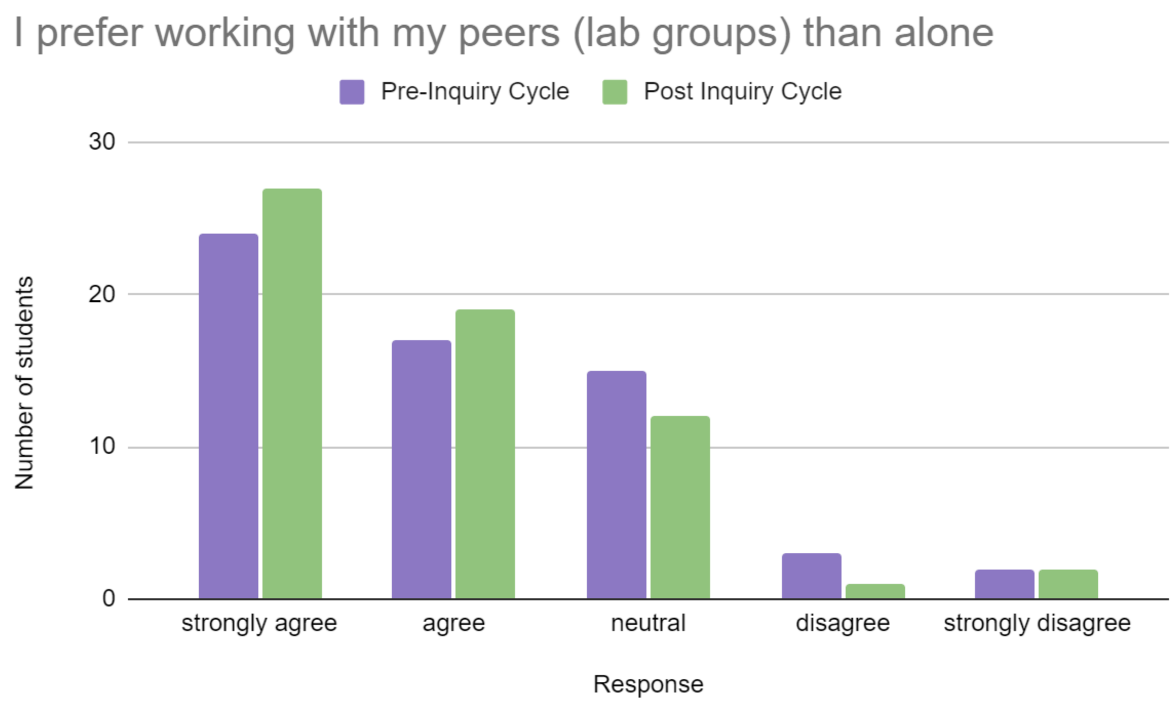
Graph 7: Pre and Post Survey results for Question 10



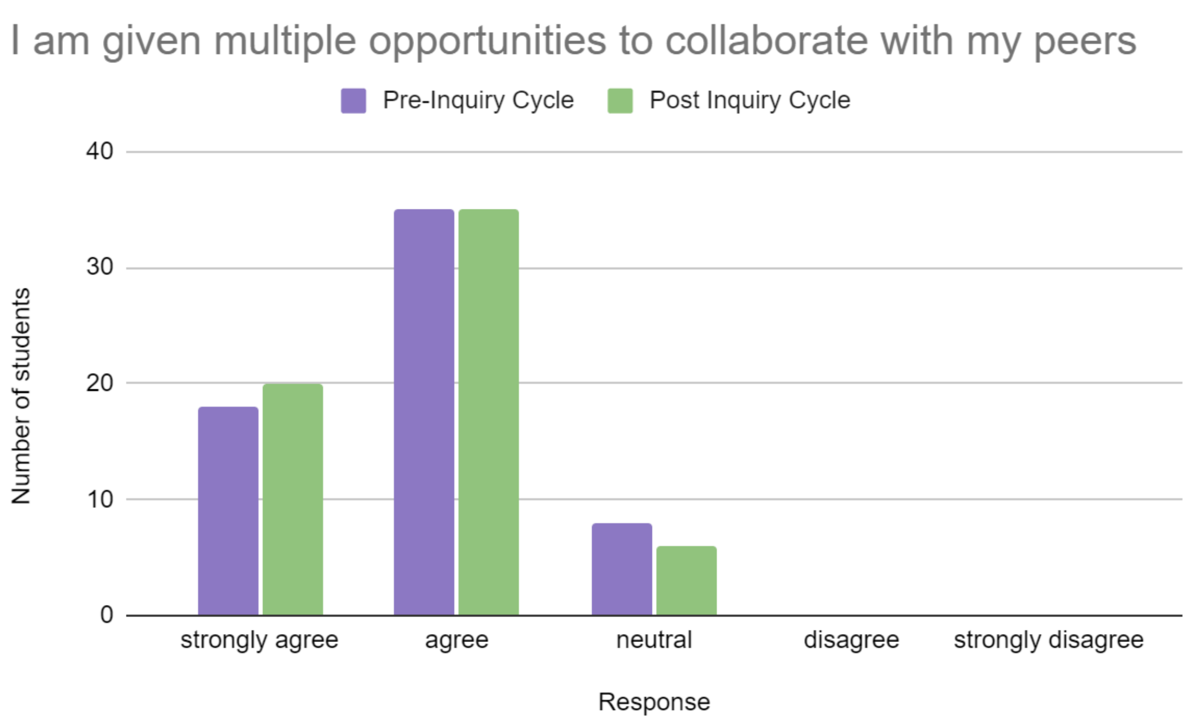
Graph 8: Pre and Post Survey results for Question 11



Graph 9: Pre and Post Survey results for Question 12



Graph 10: Pre and Post Survey results for Question 13



Graph 11: Pre and Post Survey results for Question 14

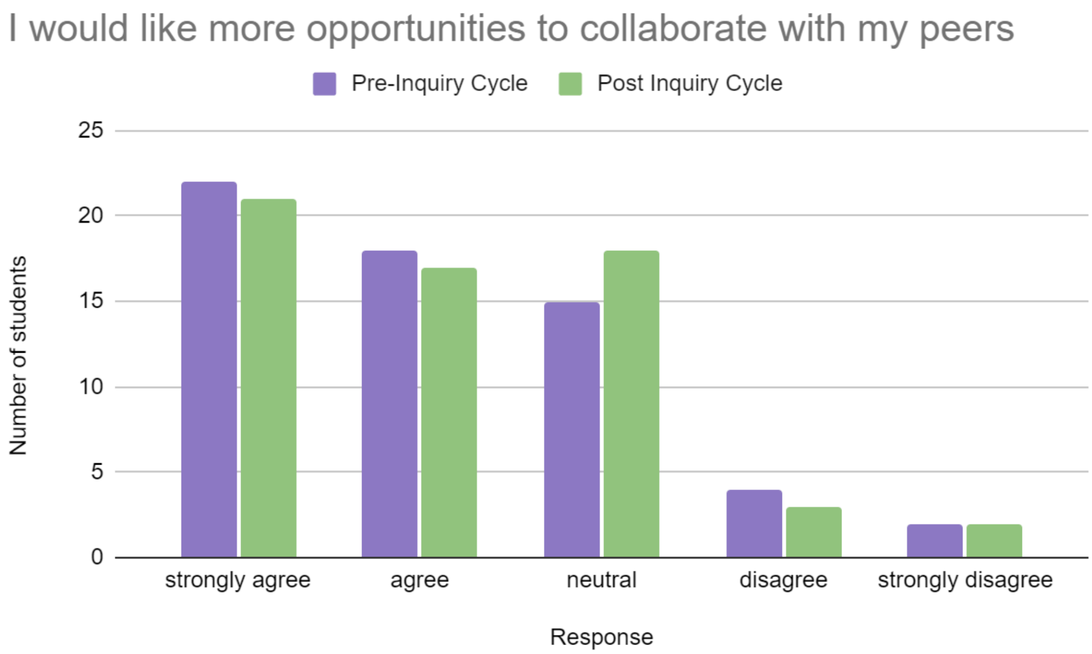


Table 1: Student Performance Across Inquiry Cycles

Student Performance Table			
	Below Standard	Meets Standard	Above Standard
Pre-Inquiry Cycle	88% (n=63)	12% (n=8)	0% (n=0)
Inquiry Cycle 1	61% (n=11)	22% (n=4)	16% (n=3)
Inquiry Cycle 2	23% (n=15)	52% (n=33)	23% (n=15)
Inquiry Cycle 3	0% (n=0)	50% (n=9)	50% (n=9)

Appendix C: Qualitative Data Analysis Results

Data Source	Participant	Quote/Example	Code	Theme
Open Ended Survey Question	MG	Response to question 15 Pre survey: " What is phenomenon???" Post Survey: "Phenomenons put what were learning in perspective. Instead of making lessons only fact based, it helps connect what we learned to the world..it helps me remember, like with the bajau people theyre something to remember which helps me remember what we are learning."	Meaning making	Negotiation of meaning
Student Work (IC3)	RH, GL, AD, MG	"the invasive species is causing the carrying capacity of Axolotls to rapidly decrease. The more invasive species that take over the Axolotls environment the fewer Axolotls there is going to be"	Student learning and meaning making	Negotiation of meaning
Student Work	CB, JD, JV	"the limiting factors are all set in place to keep balance in the environment, but the paoching of pagolins affected their limiting factors negatively"	Student sense making	Negotiation of meaning
Focus Group (IC3)	PS	"I learned alot about how there is little things that we can do to help save the orangutans, but there's also a lot that we have the government do improve it even more"	real world learning experiences	Negotiation of meaning
Researcher Journal	Researcher	Students highlighting CERs allowed students to be more concise in their claim. Students asking more questions about the difference between explanation and reasoning. I believe that students are now starting to grapple and actually start thinking about how the reasoning is an extension of their explanation.	student sense making	Negotiation of meaning
Researcher Journal (IC2)	Researcher	Students using personal knowledge of athletes to find appropriate lab or activity to use as evidence for cellular respiration CER	Funds of knowledge	Negotiation of meaning
Open Ended Survey Question	AB	Response to question 15: Pre Survey: "I dont know and I dont care" Post survey: "Because it gives me an understanding and an example of what's going on, making it easier to understand and make statements about it"	Conceptual understanding	Negotiation of meaning

Student work	FG	“Becaused he was diagnosed with cancer he should stick to moderate intensity cardio. Since he has cancer he needs to be careful so that he does not go into lactic acid fermentation and get too sore. Evidence for this is the muscle fatigue lab. When I first started the muscle fatigue lab I was able to do 35 squeezes with the tennis ball, but after 2 minutes i could only do 19 squeezes. This was because my mitochondria started doing lactic acid fermentation which created less ATP, which is why Lance Armstrong should stay away from high intensity exercise”	Sense making/ Funds of knowledge	Negotiation of meaning
Student Work	FG	"Lace Armstrong is world renowned cyclist and has won the tour de france multiple times. Becaused he was diagnosed with cancer he should stick to moderate intensity cardio. Since he has cancer he needs to be careful so that he does not go into lactic acid fermentation and get too sore."	Cultural relevance/ student interest	Humanizing experiences
Focus Group	YB	"The gallery walk was cool because it allowed us to see what everyone else had researched, and we could see what we could all do to help the other endangered animals”	Classroom community	Humanizing experiences
Focus Group (IC1)	PS	"I think when we were talking about variation, how the Bajau people have big spleens and we have regular spleens... i think it explains why were different and like we are all different for different reasons but it's because of biology”	Cultural relevance/ student identity in curriculum	Humanizing experiences
Focus Group (IC2)	JM	"When we could choose the sport and the person we talked about and how we could chose our friends" "I liked it because it made it personal to me and so it was more interesting. like to write about NG is more fun than to take a test"	Student agency	Humanizing experiences
Focus Group	YB	"because we could chose… we were able to chose people we related to, and because i play soccer I chose Messi because I know what kind of exercise he needs because i do the same kind of exercise, so i guess that is how i was reflected in what we were learning"	Student identity in curriculum/ relating to student interests	Humanizing experiences

Open Ended Survey Question	CO	Response to question 16: "Writing a CER with my lab group does help because there are more pieces of evidence and reasoning to put together, making the CER stronger."	Student interactions	Humanizing experiences
Open Ended Survey Question	MM	"It helps because you are collaborating and getting ideas from multiple people. You are getting perspectives that you would not get if you were writing alone."	Classroom community	Humanizing experiences
Focus Group (IC2)	JM	"When we could choose the sport and the person we talked about and how we could choose our friends" "I liked it because it made it personal to me and so it was more interesting. like to write about NG is more fun than to take a test"	Multiple access to learning opportunities	Equity and access
Researcher Journal (IC3)	Researcher	Student engagement increased with environmental impact CER when allowed to choose own group as opposed to assigning groups. ie IC3 had greater group engagement and collaboration compared to IC1	Student grouping	Equity and access
Researcher Journal (IC2)	Researcher	Addition of graphic organizers and idea checklists allow students to be more explicit in their CER writing.	Differentiated instruction	Equity and access
Student Work	FG	"Lace Armstrong is world renowned cyclist and has won the tour de france multiple times. Because he was diagnosed with cancer he should stick to moderate intensity cardio. Since he has cancer he needs to be careful so that he does not go into lactic acid fermentation and get too sore."	Funds of knowledge	Equity and access
Researcher Journal (IC3)	Researcher	Students highlighting CERs allowed students to be more concise in their claim. Students asking more questions about the difference between explanation and reasoning. I believe that students are now starting to grapple and actually start thinking about how the reasoning is an extension of their explanation.	UDL	Equity and access

Appendix D: Unit Plans

Inquiry Cycle 1 Unit Plan: Evolution by Natural Selection

Name: Camille Talmadge **Date: 3/6/2023**

ED 247 ADDITION

Inquiry Question:
How might the implementation of culturally relevant anchoring phenomenon encourage my 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment?

Strategy/scaffold to be implemented:
Culturally relevant anchoring phenomenon
Summary Table

Data to be collected:
Student work: Summary tables and oral CER
Researcher Journal
Focus Group

Anchoring phenomenon:
The Bajau people, an indigenous community that have adaptations such as larger spleens that allow them to spend over 50% of wake time underwater

Essential Question:
How and why are the Bajau community unique compared to communities like ours?

Unit Objective: Students will **create** an **oral presentation** by **making an evidence based explanation in the form of a claim evidence, reason statement (CER)** to **to answer the unit essential question demonstrating understanding of evolution by natural selection**.

Standards/Framework Addressed:

HS-LS4-2.

Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment

Assessment(s) (formative [always necessary], summative, self-assessments):

Summary table-formative

CER-summaritive

Differentiation/Universal Design for Learning (UDL) Strategies (list one from each category):

- **Strategie for Engagement:** Think-pair-share
- **Strategies for Representation:** Modeling an academic task - Summary Table
- **Strategies for Expression:** Exemplar - example of good CER

Give an example of how you are incorporating some aspect of your multilingual students' languages, communities, or families into the lesson.

Comparing own culture and communities traits with that of the Bajau people

Lesson Sequence	Teacher Actions	Student Actions
Introduction · Connect to previous learning · Create inquiry · Set expectations and goals · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback	● ask students to think about their cultures and communities and what traits make their cultures unique ● introduce students to the anchoring phenomena	● students share with partners about their cultures and communities ● students hypothesizing/forming initial ideas for mechanism behind Bajau communities adaptations
Body · Access new information · Process new information · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback · Includes cognitive demand	● facilitate direct instruction and supporting activities ● model how to fill out summary table for first activity	● complete summary table after each activity
Closure · Revisit learning target · Connect today's concepts/knowledge/skills to the big idea(s) of the unit · Students reflect on their learning and establish goals · Student grouping · Ways that students extend their learning beyond today's lesson	● facilitate lesson on written CER ● intentional grouping of students	● completing CER

Inquiry Cycle 2 Unit Plan: Cellular Respiration

Name: Camille Talmadge **Date: 4/12/2023**

ED 247 ADDITION

Inquiry Question:
How might the implementation of culturally relevant anchoring phenomenon encourage my 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment?

Strategy/scaffold to be implemented:
Anchoring phenomenon connecting to student interests and increases student agency
CER graphic organizer
Explanation and idea checklist
Summary table graphic organizer

Data to be collected:
Student work: Summary tables, CER organizer, written CER
Focus group questions
Researcher Journal

Anchoring phenomenon:
Athletes and how they create energy for the sports they play

Essential Question:
Who is your athlete? What food source and style of exercise would best support your athlete/yourself?

Unit Objective: Students will **construct** an evidence **based explanation** by **using evidence from breathing rate lab and muscle fatigue lab** to **support their claim of which food source and style of exercise is best for their chosen athlete**.

Standards/Framework Addressed:

HS-LS1-6.

Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

HS-LS2-3.

Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Assessment(s) (formative [always necessary], summative, self-assessments):

Summary table graphic organizer and CER graphic organizer-formative

CER-summaritive

Differentiation/Universal Design for Learning (UDL) Strategies (list one from each category):

- **Strategie for Engagement:** Think-pair-share
- **Strategies for Representation:** Modeling an academic task - CER graphic organizer
- **Strategies for Expression:** Explicit instruction

Give an example of how you are incorporating some aspect of your multilingual students' languages, communities, or families into the lesson.

Students sharing stories of what their favorite extracurriculars are and who they like to share these activities with (for example a student shared that soccer is his favorite sport because he likes to play it with his dad).

Lesson Sequence	Teacher Actions	Student Actions
Introduction · Connect to previous learning · Create inquiry · Set expectations and goals · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback	● ask students to share their personal hobbies and extracurriculars they participate in ● facilitating discussion about athletes ● introduce students to the anchoring phenomenon	● think pair share with elbow partners ● students deciding favorite athlete
Body · Access new information · Process new information · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback · Includes cognitive demand	● facilitating direct instruction and supporting activities ● emphasizing how to look for trends in data to use for evidence in summary table	● filling out summary table after each activity
Closure · Revisit learning target · Connect today's concepts/knowledge/skills to the big idea(s) of the unit · Students reflect on their learning and establish goals · Student grouping · Ways that students extend their learning beyond today's lesson	● model how to use CER graphic organizer ● implementing idea and answer checklist	● filling out CER graphic organizer ● using answer and idea checklist for CER

Inquiry Cycle 3 Unit Plan: Ecology and Human Impacts

Name: Camille Talmadge **Date: 5/16/2023**

ED 247 ADDITION

Inquiry Question:
How might the implementation of culturally relevant anchoring phenomenon encourage my 9th grade CP Biology students to analyze and interpret data to create evidence based explanations in a safe collaborative learning environment?

Strategy/scaffold to be implemented:
Anchoring phenomenon that connects to students lived experiences as well increases student agency
CER graphic organizer
Summary table graphic organizer
Explanation and idea checklist
CER highlighting
Gallery walk

Data to be collected:
Student work: CERs, graphic organizers, gallery walk responses

Anchoring phenomenon:
Human impacts

Essential Question:
How has the species population size been affected by an environmental challenge?

Unit Objective: Students will **construct** an **evidence based explanation** by **researching data on population growth sizes** to **explain how human activities impact an organism;s population growth**.

Standards/Framework Addressed:

HS-LS2-7.

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity

Assessment(s) (formative [always necessary], summative, self-assessments):

Summary table graphic organizer and CER graphic organizer-formative

CER-summaritive

Differentiation/Universal Design for Learning (UDL) Strategies (list one from each category):

- **Strategies for Engagement:** Brightly colored high contrast materials - highlighting CER
- **Strategies for Representation:** Modeling an academic task - gallery walk response
- **Strategies for Expression:** Rubric

Give an example of how you are incorporating some aspect of your multilingual students' languages, communities, or families into the lesson.

Sharing out students favorite ways to connect with the environment

Lesson Sequence	Teacher Actions	Student Actions
Introduction · Connect to previous learning · Create inquiry · Set expectations and goals · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback	● ask students to think about the ways in which they interact with the environment ● teach students to calculate their ecological footprint	● reflect on ecological footprint and the ways in which they interact with the environment
Body · Access new information · Process new information · Student grouping · Scaffolding for diverse learners · Evidence of student learning · Monitor/feedback · Includes cognitive demand	● facilitating direct instruction and supporting activities ● mini lesson on each human impact ●	● filling out summary table after each activity
Closure · Revisit learning target · Connect today's concepts/knowledge/skills to the big idea(s) of the unit · Students reflect on their learning and establish goals · Student grouping · Ways that students extend their learning beyond today's lesson	● model how to highlight/ color code CER ● passing out graphic organizer ● facilitating gallery walk	● filling out CER graphic organizer ● using answer and idea checklist for CER ● highlighting CER ● interacting with peers CERs ● developing solutions to peers human impacts

Appendix E: Student Sample Work

Inquiry cycle 1: Evolution by Natural Selection Summary Tables

STUDENT 2

My Thoughts Summary Table + 5/5

Name: M[redacted]h **Per:** 4th

Phenomena: The Batau people spend 60% of their time underwater. They can hold their breath for a long time, They can dive 250 feet / 70 meters underwater.

Driving Question(s): How and why are the bajau people unique compared to comunities like ours?

Activity (Concept)	Observation, Evidence, and/or Patterns	Explanation	Connection to Phenomenon
Rock pocket Mouse	I noticed Reproduction in the activity due to the dark mice reproducing and passing down its genes	Reproduction allowed the dark mice to multiply -Dark mice were more comon in the dark enviroment = camoflage → Survive	Reproduction allowed the Bajau people to pass down the big spleen genes to their children or next generation.

spleen.

variation, competition, natural selection, survivals, reproduction

when the environment change.

The bajau people are unique to us because they have spleen and flippers. because of Adaptations

STUDENT ONE

My Thoughts Summary Table + 5/5

Name: C[redacted] **Per:** 4

Phenomena: The Bajau people spend 60% of their time underwater. They can hold their breath for a long time, they can dive 250ft. on water

Driving Question(s): How and why are the Bajau people unique compared to communities like ours?

persisted community — adaptations — Spleen, eyes, flippers

Activity (Concept)	Observation, Evidence, and/or Patterns	Explanation	Connection to Phenomenon
Theme chosen: Adaptation Activity: Rock pockets mice.	1st: In my the rock pocket mice, Adaptation of light skin to dark play a factor of survival White mice that didn't adapt dark skin to blend with volcano rocks	Because adaptation is important to survival, it shows how certain species "adapt" to survive, eat, and reproduce. Those who can't adapt will die	Adaptation relates to the bajau people because the best of the's species had adapted to breathe in water longer, their eyes survive, and have skin fins.

Adaptation

Phenomena: The Bajau people spend 60% of their time underwater. They can hold their breath for a long time and they dive 250 feet (70 m) underwater.

Driving Question(s): How and why are the Bajau people unique compared to communities like ours?

Activity (Concept)	Observation, Evidence, and/or Patterns	Explanation	Connection to Phenomenon
Peppered Moth Survey	-competition between the white and peppered moths based on the color of the background	-predators ate contrasting moths -camouflaging moths outcompeted contrasting moths	with large spleens -competition between large and smaller spleens -large spleens outcompeted smaller spleens in underwater environment

Inquiry cycle 2: Cellular Respiration CER

Skilled Student Work Sample

Claim:Leo Messi is a soccer player most known for playing for the Argentina football team. Messi is a forward and has even won the Fifa World Cup. Because Messi needs to keep up his stamina and maintain high levels of energy he should do high intensity exercise such a lifting weights and doing cardio. He should also eat carbohydrates to maintain his energy.
Evidence:When we were doing the breathing rate lab, my breath rate was 16 breaths per minute. After doing the jumping jacks, my breath rate increased to 20 breaths per minute. When we were learning about cellular respiration we saw that carbon dioxide is an input and oxygen is an output. If my breath rate increases that means i am taking in more carbon and breathing out more oxygen. This means that the rate of cellular respiration has gone up. This also means that I am making more energy because ATP is also a product of cellular respiration. From our notes we learned that glucose is a carbohydrate and the first stage of cellular respiration is glycolysis which means splitting glucose.
Reasoning:This proves that high intensity exercise is good for Leo Messi because he needs to make a lot of ATP to maintain his energy, so he should keep exercising alot so that he keeps doing cellular respiration at a fast pace. Eating carbohydrates also helps because it is necessary to start cellular respiration.

Proficient Student Work Sample

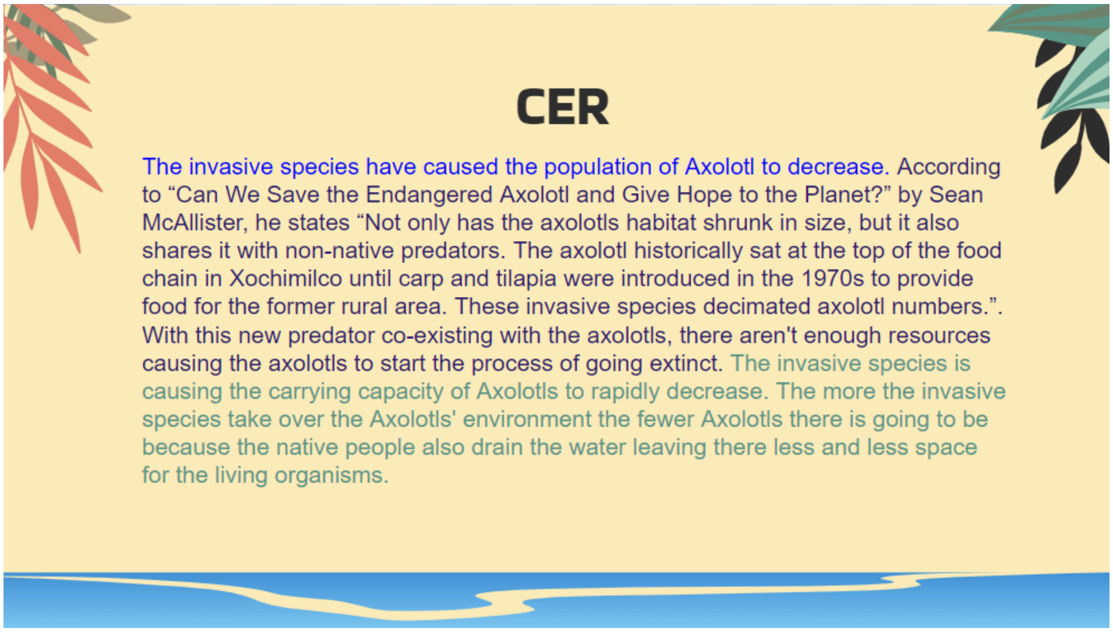
Lace Armstrong is world renowned cyclist and has won the tour de France multiple times. Becaused he was diagnosed with cancer he should stick to moderate intensity cardio. Since he has cancer he needs to be careful so that he does not go into lactic acid fermentation and get too sore. Evidence for this is the muscle fatigue lab. When I first started the muscle fatigue lab I was able to do 35 squeezes with the tennis ball, but after 2 minutes i could only do 19 squeezes. This was because my mitochondria started doing lactic acid fermentation which created less ATP, which is why Lance Armstrong should stay away from high intensity exercise. Also eating glucose is good for glycolysis.

Developing Student Work Sample

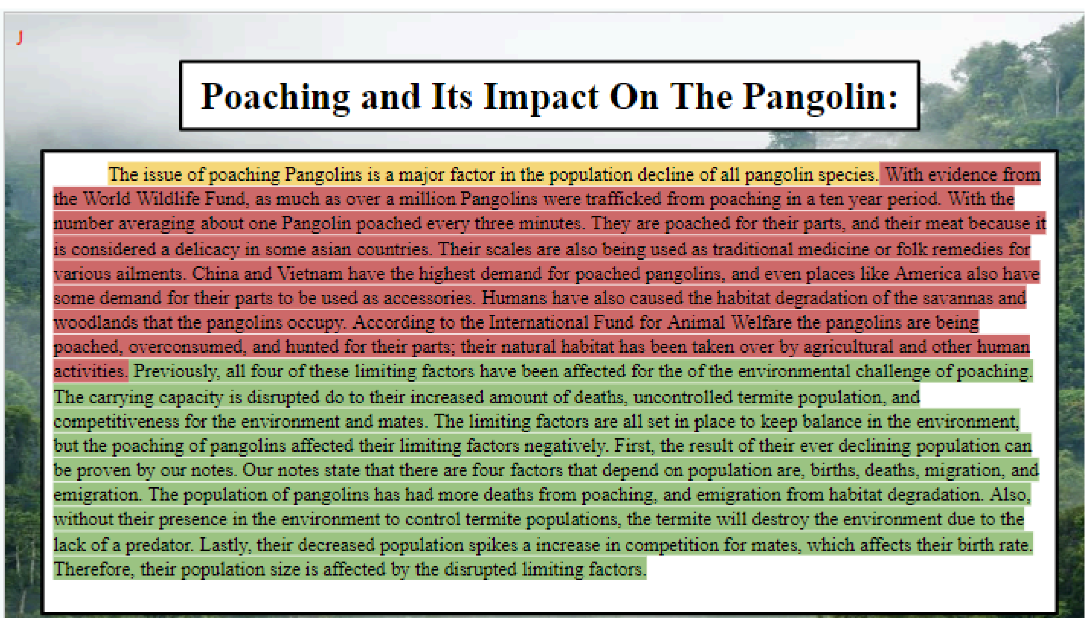
Bethany hamilton is a famous female surfer. She was attacked by a shark and lost her arm. Because she only has one arm she should take it easy on exercise and eat a lot of protein. protein is good for building muscle and she needs to not work out too hard s=or she she will get more injured

Inquiry cycle 3: Ecology Final CER

Skilled student work sample



Skilled Student Work Sample



Proficient Student Work Sample

CER

How has the species population size been affected by an environmental challenge?

Claim: Human consumption in the form of poaching has made the elephant population plummet.

Evidence: Poachers kill around 20,000 elephants every year for their Ivory. Many species of elephants are now critically endangered due to illegal hunting. Poaching increases competition and lowers elephant numbers.

Reasoning: Poaching is a human interference, and it's an unnatural limiting factor which negatively harms the population as they cant sustain their numbers due to the excessive killing of the population. This makes it difficult to mate and disrupts the population numbers drastically. Furthermore, poaching makes their predators compete for food as there's less of it. The predator numbers start to decline as well as a result of the lower elephant population. Animals like crocodiles, lions, and hyenas are directly affected and harmed by this.

Appendix F: Rubric

Formative Assessment Rubric (adapted from Kang et al. 2014)

	Developing	Proficient	Skilled
Framing of Explanation	Weak link between observable phenomenon and unobservable concepts Restating textbook explanation	Describes relationships between phenomenon and proposed unobservable concepts without reasoning through data or scientific ideas	Shows causal link between phenomenon and proposed unobservable concepts and constructs explanation though reasoning through data or scientific ideas
Role of Evidence	Explanation is not supported by any form of evidence	Explanation refers to activity or data as evidence or connection between evidence and explanation is weak	Explanation highlights key patterns of data or observations or activities or connection between evidence and explanation is strong
Depth of Explanation	"What" Describing observations without suggesting cause	"How" Focus on causal relationship - no attention to underlying mechanisms	"Why" In-depth explanations that provide full causal relationship between phenomenon and unobservable concepts to explain patterns of evidence
Coherence	Explanation covers bits or pieces of information about phenomenon but no causal connections	Explanation is partial some parts are incoherent or inconsistent with data or scientific concepts	Explanation is gapless and logical, no conflict with data or scientific concepts

Student Self-Assessment Rubric

	Help!	I can do this with support!	I can do this on my own!
Framing of Explanation	My explanation does not show a link between observable phenomenon and unobservable concepts I restate the textbook explanation	My explanation describes relationships between phenomenon and proposed unobservable concepts. I do not use reasoning through data or scientific ideas	My explanation shows a causal link between the phenomenon and proposed unobservable concepts. I construct an explanation by reasoning through data or scientific ideas
Role of Evidence	My explanation is not supported by any form of evidence	My explanation refers to activity or data as evidence or the connection between my evidence and my explanation is weak	My explanation highlights key patterns of data, observations or activities, or the connection between my evidence and my explanation is strong
Depth of Explanation	"What" I describe observations without suggesting cause	"How" I focus on causal relationship and I do not describe underlying mechanisms	"Why" I give in-depth explanations that provide full causal relationship between phenomenon and unobservable concepts to explain patterns of evidence
Coherence	My explanation covers bits or pieces of information about phenomenon but I do not include causal connections	My explanation is partial some parts are incoherent or inconsistent with data or scientific concepts	My explanation is gapless and logical, and has no conflict with data or scientific concepts

Appendix G: Focus Group Questions

Inquiry cycle 1:

1. Did you see yourself, your culture or community reflected in the anchoring phenomenon of the Bajau community? Why or why not?
2. Did you find the Bajau community interesting?
3. Did returning the Bajau people help to motivate you in understanding the concepts of natural selection?
4. Did you enjoy working with your peers or would you have preferred to work alone?

Inquiry Cycle 2:

1. How did you see yourself, your community or your culture represented through the anchoring phenomenon?
2. Did you find the anchoring phenomenon interesting?
3. How did the graphic organizers help you to analyze data from the labs?
4. How did the anchoring phenomenon help you to understand the process of cellular respiration?
5. What did you like or dislike about the anchoring phenomenon?

Inquiry Cycle 3:

1. What did you learn about the ways in which you interact with your environment through this project?
2. How did the project allow you to see yourself, your cultures and communities?
3. How did the project help you to develop solutions to the ways in which humans cause harm to the environment?
4. How can you apply what you have learned from the gallery walk to your personal life?

Post-inquiry:

1. How did having a choice for the topic of your CER compare to not having a choice for the topic of your CER? Which would you prefer?
2. Could you explain the scientific process and principles learned about in class without an anchoring phenomenon?
3. How did the anchoring phenomenon help you to analyze data?
4. Did you enjoy the gallery walk? How did it help you to connect with your peers and with the science concepts?
5. Would you recommend more science teachers to introduce phenomenon based learning?