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Effects of Ambitious Science Teaching Pedagogy on Building a Positive Classroom Community

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ABSTRACT

Ambitious Science Teaching (AST) supports positive classroom community. AST is an inquiry-based pedagogy that used phenomena and the concept of the scientific methods for students to understand science concepts. AST focuses on equity, student-led learning, and discussion-based rather than lecture-based lessons. An example of AST was observed through a middle school 6th grade science classroom during an eight-week timespan. This school has been using AST at the middle school science classrooms for years. The observations covered one whole AST unit in which the phenomena of focus was Acorn to Oak. The observations from the AST classroom were then categorized into the 3 aspects of positive classroom community: mutual accountability, shared concepts created by the class, and diverse engagement. Positive classroom community allows for students to be comfortable sharing ideas while discussing and improving explanations of science concepts. This thesis investigates the possible connection of AST and positive classroom community.

Keywords: Classroom Community, Ambitious Science Teaching, Phenomena-Based Learning, Middle School

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Chapter 1

Introduction

This thesis is investigating possible evidence for the connection between the Ambitious Science Teaching (AST) pedagogy and classroom community, specifically positive classroom community. All data was collected as observational research in a 6th grade classroom at a middle school. These observations occurred during pre-service teaching as part of the Pennsylvania State University teacher education program for secondary science education. In the eight-week period students completed one unit. The first day of observations occurred on the students first day of school and the last day was when the students completed their unit test. It is rare to see research that studies these two specific concepts together. AST is a newer pedagogy that is different from more traditional methods. This has made it a less researched topic since it is not as well-known and not many schools have established teaching methods based on AST.

The mentor teacher had used the AST pedagogy for ten years. Science student teachers observe this school's science classes since this is the pedagogy taught in Penn State science teaching methods classes. AST focuses on moving away from surface level vocabulary-based science education and pushing toward a deep understanding of concepts. Students are usually guided in figuring concepts out on their own rather than being told how a concept works. AST based units usually start with something called the anchoring phenomena. This is defined as "any complex phenomenon for which students can develop models and explanations over the course of the unit." (Windschtil et al., 2020). In the observed unit, this phenomenon was a video of an acorn growing into a sapling that was sped up to be seen in a few minutes. The teacher also showed students an adult oak tree on the school property to give an even better understanding of the scale for these students.

Following this the students were given a series of activities to see different aspects of the multitude of processes needed to explain the anchoring phenomena at the end of the unit. These units are typically longer than a chapter-based unit since chapters of a textbook cover one overall topic while these units have multiple topics due to the complexity of the phenomena. The observed unit needed to explain how the cells divided, how it got nutrients from the environment, and how the plant got energy. A breakdown of the unit topics and activities is in Appendix A.

AST pedagogy also tries to emulate the scientific process in how the unit is designed. The cornerstone of the scientific method is that experiments are conducted to answer a question. This relates to the NGSS science and engineering practices that focus on overall ideas of science like building models, understanding graphs, and using data to make conclusions. Furthermore, the students must collect their own data which they called evidence to support the reasoning of their claim. This claim was what students believed happened during an experiment. The claim often was a definition of a process or a model. For example, an activity involving shell-less eggs in salt water and distilled water was used to see the eggs' mass difference after a certain amount of time. Using their data students defined osmosis as the diffusion of water across a membrane. Students had defined diffusion in a previous activity. In AST there is no right or wrong answers just better or worse explanations that can continually be improved.

Discussion is an integral part of AST, particularly increasing discussion between students. The idea is to avoid teachers lecturing on topics. Students collect observations in activities that they discuss in different sized groups to get to the concepts themselves. The teacher functions as a guiderail in these discussions to make sure they do not veer too far from the main concept. Also, the teacher needs to facilitate student to student discussion. The goal of

these is to have students go beyond agreeing or disagreeing with classmates but also be able to give reasoning to their response. The ideal outcome is to have students combine classmates' ideas with their own to improve their explanation of the investigated concept. This combination of ideas also supports their ongoing thinking as they develop those explanations.

AST is designed for students to have a lot of power in how they get to the phenomena's explanation. In the discussions, the questions are responsive to where the students are in their understanding and once asked the teacher allows the students to discuss among themselves. Students are encouraged to share their own ideas that are supported by evidence rather than opinions or what they might remember that they saw in a video or book. The teacher gives very little direct lecture-type instruction. The investigation of concepts occurs in a controlled manner. Both in terms of the experiment as well as the method of data collection. For younger students they are told how to collect their data but as the students have more practice in the pedagogy the students design their own experiments but are led to the type of experiment that will give them the best results. Though the activities themselves and the questions to start discussions are more controlled, how students choose to organize and use that information is up to them. The chosen questions are designed to elicit student ideas. Teachers that use AST are trying to tap into students' natural curiosity. If a student asks a question and it cannot be answered now the teacher tries to come back to that question if will be a benefit to the class overall.

Lastly, equity is an important goal of AST. AST is structured to make science accessible to all students. Some specific areas of accessibility are language as well as relevance for the students. Stripping the vocabulary focus from lessons helps all students begin from a common point no matter where they may have started in their knowledge at the beginning of the unit based on prior experience (Windschitl, 2020). This was often seen in how the students would use

their own words when first investigating a certain concept. The teacher would give students the actual word after they already understood and defined the concept. For example, when students needed to understand living things are made of cells, they looked at different living things like onion cells and pond water microorganisms under a microscope. They called cells “shaps”. Teachers also try to choose phenomena that are relevant for the student based on the community that the school is in or everyday experiences in the home. This brings real life experience into the classroom and removes the question of why science is important to their lives. The incorporation of everyday experiences mitigates the need for students to have enrichment opportunities at home that not all may have access to (Windschitl, 2020).

Classroom community is the other focus of this thesis, specifically how to identify the classroom community as positive. Community is looking at interactions and behaviors of a group of people in a specific setting. In this case the setting is a science classroom of 6th grade students and how they interact with classmates and the teacher as well as the routines of that classroom. For a classroom to have positive community there needs to be mutual accountability by all members of the community, shared concepts created and agreed to, and diverse engagement by all members (Wenger, 1998). These three pieces allow for students to feel comfortable and safe in the classroom, allowing them to share ideas and engage with the class. Furthermore, it helps students by creating a community that students know will support them in academic contexts as well as others.

Mutual accountability is the concept where all members of a group understand some agreed upon set of values. The members also need to make sure that other members adhere to the expectations and values of specific situations and events in a community (Wenger, 1998). In a classroom students need to understand what is expected of themselves and their classmates.

Furthermore, students need to understand the values of an AST based classroom. A value in an AST classroom would be originality. The value of originality creates the expectation that evidence like observations are required to support any claim that is made. This piece of positive classroom community allows there to be clear expectations and values for all members of the group. There is a comfort of normalcy in clear expectations. Moreover, it avoids authoritarian environments where students are told all the rules without any input. The students have a hand in how this is created and can sometimes hold each other accountable to following those expectations.

Shared concepts are when an agreement is made on how a concept is modeled or defined. This must be reached by combining ideas from all members of the community and is a definition or model all members believe to be true. In AST classrooms an example would be how vocabulary is defined, the model for a scientific process, and a set of agreed upon observations from the anchoring phenomena that need to be explained to create a good explanation of the phenomena. Allowing all students to contribute on their understanding of concepts builds an environment where all ideas are respected and given equal consideration.

Diverse engagement is the last aspect of positive classroom community. What diverse engagement means is there are different ways that members can contribute or interact with the community. This allows for more overall participation since members engage in the way that is the most comfortable for them. In an AST classroom, students have a variety of ways to share ideas when trying to create models or engage in discussions. These practices go beyond just directly sharing in front of the whole class since this is uncomfortable for some students. This is positive classroom community since the variety of opportunities allows for contribution, respects

all student ideas, and respects the ways in which students engage with classmates in their class community best.

Chapter 2

Literature Review

The current literature related to AST and positive classroom community studied together is limited. There is quite a bit of research on classroom community but as a newer pedagogy (the oldest article found about AST was published in 2017) there is less research related to AST. The literature that exists is not quite the age range of the observed students or is researching another topic with AST that is not classroom community. Some of the AST articles are studying students at the college level or focus on the education of student teachers. As schools in Pennsylvania are using the new updated state science standards which are aligned with the Next Generation Science Standards (NGSS) there might be a shift in pedagogy towards AST. These standards focus more on skills that students need to master for science like reasoning and graph interpretation rather than vocabulary knowledge. This focus on science skills aligns more with AST. These are called science and engineering-based practices. There are eight that are present in the NGSS which are: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (*Home Page: Next generation science standards)*

One of the articles on AST was researching how the responses of the TAs in AST-based discussions affected the explanatory rigor of students' responses in an undergraduate biology lab (Grinath & Southerland, 2019). This was one of the closest articles on AST that related to classroom community. This article focuses on the discussions that occur and how the discussion starts and is moderated by the TA in a college freshman biology lab. The discussion foundation

of AST comes up in the research, but this is only one piece of how the community created by AST practices also affects other areas like student behavior, interactions, classroom routine and responses. As a result, they focused more on transcribed discussions and response content rather than observations of student behaviors and classroom routines.

The article covered two semesters of college biology labs and included several TAs that were all given professional development on AST-based discussions. The article had a comparatively large sample size of students. The two semesters totaled around 1,400 students between all the different TA's labs (Grinath & Southerland, 2019). This number of students is rare in education research particularly with younger grades. This research being conducted at the college level probably explains how the researchers were able to generate the large sample size of students since introductory biology classes tend to be large, have multiple lecture sections, and many different lab sections. In another older article that talked about an inquiry-based instruction prior to AST truly being formed they only had 2 classes of students participating but the research was conducted at the middle school level (Berland & Reiser, 2011). Teachers at younger grades see fewer students throughout the day due to smaller class sizes. The research in this thesis is limited by this factor as well due to limited available time to observe students during pre-service teaching as well as being assigned to a single mentor teacher.

Often all science research at higher levels of education focuses on one science subject, like biology in the case of the article. Often as students move from middle school to high school, science topics separate into different classes like biology, earth and space science, chemistry, physics, and others. This is especially true in college where there are a variety of classes that fall into each of those categories. An article by Forman *et al*. (2017) looked at discussion-based strategies in a high school biology classroom and how they build community. While the article

by Berland & Reiser (2011) looked at a middle school classroom and there was no specific science subject chosen, it was general science.

Grinath & Southerland (2019) give a breakdown of exact participant numbers, number of males and females, and the academic year of the students. Many articles did not give as detailed a description of the demographics of students. Stoup & Hancock (2022) were examining the mentoring of pre-service teachers by their mentor teachers regarding AST as well as mentor teachers' participation in professional development. They listed how many mentor teachers participated and gave some information about the ones that the results are mainly based on. There is little to no information about the pre-service teachers themselves even though information from them was a data source (Stroup & Hancock, 2022). This takes away from their method's information since they talked about how they collected data but gave less focus to who they collected data from which is important for analysis of the results.

This was a good article on AST, with effective research methods that enhanced the conclusions given by the researchers. Though the main point of the article was to analyze the effectiveness of AST-based discussions in the classroom. Basically, evaluating its effectiveness as a teaching tool. This is a common goal in AST research. It is different from the overall goal of this thesis which is look at AST building positive community rather than its effectiveness in teaching material. The articles showed different aspects of AST in different grade levels or contexts which went beyond my own personal experience. The articles on community were also especially important since there is not one way that community can be defined, and I personally was not sure what how to define community. I had a general sense of community but finding the words to actually define what it was required research.

Chapter 3

Methods

This investigation was conducted through observations in a 6th grade advanced science classroom. In this class they used the AST pedagogy and since the class was advanced, they covered 6th and 7th grade curriculum in the same year. Having this advanced class was new at this school. It was actually the first year trying out this particular class. It was the same curriculum but sped up meaning there were some slight differences compared to typical classes. For example, students were usually not given homework in the typical version of the class, but these students had occasional homework, usually a short writing assignment. This writing assignment called a claims evidence reasoning (CER) is where students write about some small experiment that occurred in the class and give their claim of what it means, their evidence to support their claim and their reasoning of why their evidence supports that claim.

In terms of the students and the classroom. It was a class of 18 students. There were 9 girls and 9 boys. All students were in 6th grade. Some students had gifted individualized education plans (GIEPs) and one student had an individualized education plan (IEP). These plans basically cover accommodations or differentiation that are required in schools and contain goals that are set for a student's education. It was a small room and was setup so that the students were in groups of 3 or 4 at small tables around the perimeter of the room. In the center of the room there was tables put together into one big table called a mega desk that was used during whole class discussions. Figure 1 below shows a diagram of the set-up of the classroom. The students met every other school day since the school had block scheduling with 80-minute blocks.

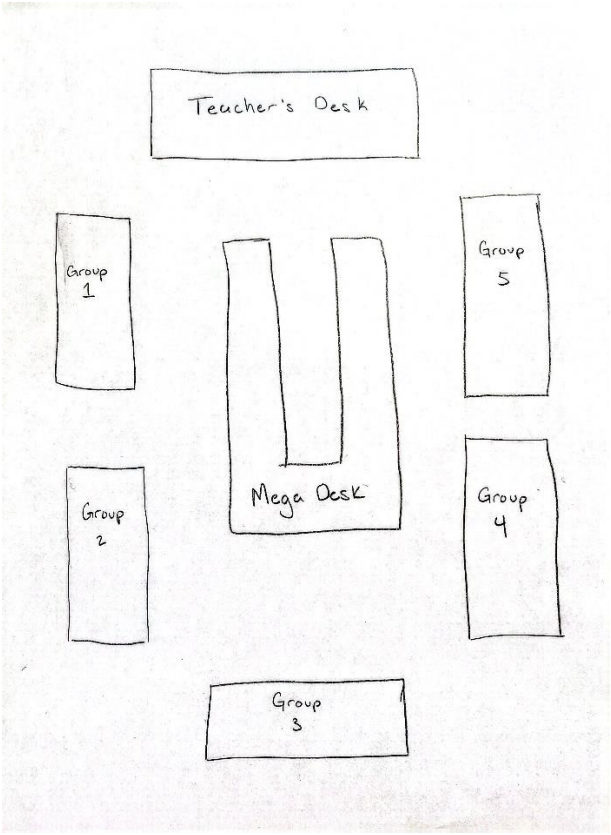


Figure 1. Diagram of Observed Classroom Layout

The observations were collected during an eight-week period during my pre-service teaching. The observations were collected in a notebook as I observed the classes. These observations were in the morning every other day when the students had the class. The observations were all collected from the same group of students. The observations started on the first day of school for those students. The unit that was observed was the acorn to oak unit where students engaged in different experiments to be able to explain all the processes that allow for an acorn to grow into an oak tree. These included topics like photosynthesis, mitosis, and diffusion and osmosis. The full list of topics and their connections to the acorn to oak unit is in Appendix A.

Once the observations were collected, they were categorized based on the definition of positive classroom community. This definition was made based on a text describing classroom community called Communities of practice: Learning, meaning, and identity (Wegner, 1998). Positive classroom community is defined as an environment where all students have set expectations that all members are mutually held accountable to, where concepts are created through class agreement and students have a variety of ways in which they can interact with other community members within the classroom. There were general overall observations collected as well as observations for the three different categories which were mutual accountability, shared concepts created by the class, and diverse engagement. The observations that were collected were student interactions with the teacher, student to student interactions, as well as different routines that were established in the classroom.

The literature research relied on the Penn State library for many of the articles that were related to the topics. The articles from the library gave a sense of what literature was available and existed on this subject. The AST book majorly contributed in terms of definitions and explanations of the pedagogy. There were also texts recommended by my thesis advisor that helped guide my investigation as well as my methods used to collect and categorize my observations.

Chapter 4

Observation Results

These are overall observations from the eight weeks in an accelerated AST classroom with 6th grade students. In this classroom the set-up was that students sat in five small groups of three or four students and there was a large table in the middle that the class could sit around that was used for whole class discussions. Starting with the first day of school the students when they first came in separated by gender and by who they were friends with. The students spoke with each other and talked about their class schedules as well as what they had done over the summer. The teacher then counted off by one through five and the students were randomly placed in separate groups. The students spoke less with the members of the group after being split up. They talked more when they were discussing an activity. This activity on the first day was meant to help students understand the difference between observations and inferences. They started working on their own and then the students were instructed to work with their groups. Later in the eight weeks students spoke more with their group members as time went on. Students also were more likely to share ideas and discuss them. Some groups did have issues getting along and had more issues working together where they rarely shared ideas or when working together on a google slides slideshow. While working on the slideshow, they would kick other group members out or edit other groups members slides.

Large group discussions showed a similar pattern of behavior change relating to participation and interactions with other students. Students usually had one or two whole class discussions every week. These discussions were set-up so that students used their evidence and reasoning from discussions with their small groups and shared it with the entire class to come to a claim about what happened during a certain experiment. During the first discussion while there

was good participation it devolved into frustration and arguments when they first started having whole class discussions. The main frustration for students seemed to be that they were not given the answer right away and many wanted to talk about things they had heard from their parents or other sources rather than using the evidence they had collected from their experiment. When the class was discussing how plants got energy students wanted to say photosynthesis, but students could not actually explain what that process was. The teacher mainly let the students talk amongst themselves and described his role as that of a guiderail. He mainly stepped in if the students seemed to get stuck or go too far off track, he would ask questions that would get students back in the direction he wanted. For example, when students were using shell-less eggs to understand osmosis he drew the diagram, shown in Figure 5 in Appendix B, which gave students a better idea of what they were looking at. This was done after students seemed to get stuck. He also explained to students that he wanted them to not just agree or disagree with other students' ideas; he wanted them to give reasoning why and he often told students he wanted them to build on and combine other students' ideas with their own to improve their own reasoning.

Mutual Accountability

Mutual accountability is one of the aspects that define community for the purpose of this investigation. The class had a lot of areas where accountability was critical. One area was that students were made accountable for their own knowledge in many ways. Students were all supposed to keep track of their own observations in their science journals. Students also had to write their own directions for certain activities if it was something they would regularly need to do throughout science classes. An example of this was that students had to write their own directions for how to prepare a microscope slide after watching the teacher go through the

process a few times. The teacher sat in the middle of the room at mega desk and all the students gathered around. The students saw that they had to place their sample on the slide, which was cheek cells for one demonstration, add water and then place a coverslip over their slides which they wrote in their journal. Also, all the students needed to make sure they had all the data from their experiments and the teacher made sure the students had time to go through the information with their groups and made sure that everything was recorded. The teacher also gave students the option to revise homework assignments based on feedback, but they had to tell him which ones to go back to regrade. For regrading at the end of the unit he gave students a notecard and they had to write their name, period, and which CERs if any they wanted him to regrade. This was mutual accountability between the teacher and students.

There was also accountability between students. During lab students expected their group members to complete their assigned tasks for an experiment. For example, labs that needed a timer or stopwatch a specific student would make sure they kept time. Students also held each other accountable during discussions. At first, the teacher had to remind students that they needed to use evidence to support their reasoning, but later students started to call out other students if they were not using evidence to support their reasoning during the whole class discussions. Usually this occurred when a student started talking about something that they heard outside of class in something like a YouTube video.

Shared Concepts Created by the Class

There were a few observations that fell under the classroom community aspect of shared concepts. One of the most overt shared concepts was the list of agreed upon observations that was made for both the unit phenomenon as well as the small experiments that were part of the

unit. This class list of observations (Figure 2 Appendix B) was made by having students volunteer their observations and they would be written in the class journal which was shown using a doc camera. Students often added the observations written in the class journal to their own science notebooks if they did not have a certain observation already written. Often the class would come up with shared definitions for certain science words. An example was a definition that students made for diffusion which was "diffusion is where there is stuff that spreads to where there is not until the stuff is evenly spread out."

Whole class discussions built on shared concepts since often these whole class discussions were where these definitions were made by the students. Student discussion also led to their claim of what was happening and built the reasoning that most students used in their explanations of certain concepts. Often small groups could differ greatly in terms of possible explanations and reasoning but after the whole class discusses they agree on a shared concept that the students came up with in a controlled way. For example, in one lesson students were instructed to make a model of mitosis with their groups based on the pictures of certain cells at different stages of mitosis. There ended up being three different possible models of mitosis that students made. There were two sets of two groups that had similar models that the teacher combined. Yet after they had a whole class discussion where they shared with the class and discussed the reasoning behind the models, they all ended up agreeing on one model as their shared concept of mitosis.

Diverse Engagement

Diverse engagement means generally that there is diversity in what is shared by the students and where they share their ideas. This was another aspect used to define community for

these observations. In the shared concepts section, it was mentioned that students' ideas that were presented during discussions could be very different. This is one part of the diverse engagement that was observed within the classroom. The variety of ideas shared by students were readily shared by these students both in small group and whole class discussions. The teacher's belief that students need to go beyond just agreeing and disagreeing and use other students' ideas to build better explanations would not work without diverse input of ideas. When students were doing a lesson on organelles, students looked at numbers of certain organelles within different cell types with differing functions. When students first started looking at the data, they were not quite sure what the functions of the organelles were but as more ideas were given by the different students in the class, they discussed why that would make sense or not and work together to reach agreed upon claims for the functions of specific organelles.

When and how students participate also contributes to observations of diverse engagement. Students had a variety of opportunities of where they could share ideas. These opportunities included individual time where the students could record their own thoughts, small group discussions where they spoke with their group of three or four students, and whole class discussions. Every student seemed to participate at an individual level where they wrote their own ideas and reasoning. Engagement in small and whole class discussions varied. In the large group all students had the choice and ability to participate and engage with the discussion. The teacher gave the students a racquetball that functioned as a talking piece. The student that had the racquetball was the only one who spoke, and they gave the ball to the next speaker. Typical large group discussion behaviors were observed where a couple students shared a lot of ideas and thoughts but there were also ideas from small group discussions that were shared even if not all students shared with the whole class.

Chapter 5

Discussion

When looking at the overall observations from an AST classroom there are some things that you might see in a typical classroom. Whether that was the observed dynamics of students in certain settings to how they organize themselves into groups when allowed to choose their own. Typical behaviors observed on the first day of school were students sitting with friends and classmates that they knew as they caught up on what happened over the summer. Girls sitting with other girls and boys sitting with boys seems to be a common occurrence in any grade in my time as a student teacher. I think splitting up the groups the students chose for themselves changed the dynamics for many of the discussions. It was informational for choosing the next seating chart based on which students seemed to not work well together both from the small group and the large group discussions. Some of this was based on how different personalities worked together. Without the level of observed discussion, it would be harder to gauge the personalities of the students and which students would work better together in the small groups. Also, the fact that the teacher rarely actively led the discussion and mainly let the students take the discussions where they wanted within reason allowed more time for the students to discuss with each other rather than the teacher. The students also had to adjust to the idea that there were no right or wrong answers. This was a big adjustment particularly for these students since they were in the advanced class. Many of them were used to school being a certain way so when that was changed it was an adjustment. Some students pushed back due to frustration at not being given the answers right away and having to figure it out on their own. Others wanted to show off what they had read, learned in videos, or from their family. Setting the expectation that the students need to use the evidence from class experiments to support their claims took a while to

sink in and many also wanted to share their opinions even if they could not support them with evidence. Lastly, the students wanted to use scientific terms that the students did not understand since as soon as students were asked to explain or define that term, they had no way to explain it. This was where the community building supported the students in accepting these new expectations that students had almost no prior experience with and were different from traditional teaching methods.

Mutual accountability was integral to how the classroom ran. The expectation of students being responsible for their own notebooks and assignments, as well as how to present information in the class were part of the classroom community. These expectations supported the community since it was constant reinforcement during everyday routines that were experienced by the students. The students holding each other accountable showed how invested they were in this community. Like when students corrected other students if they did not present evidence for their explanations particularly in group discussions. This level of investment in the community by the students is what allowed it to be positive. Routines made the teachers job easier since discussions required less moderation, and this worked toward the goal of students discussing mainly among themselves rather than relying on the teacher to lead discussions. The responsibility for their notebook and having students write their own directions for typical processes like making a microscope slide taught important lessons about true science practices which is a foundation of AST. These practices established the accountability for individual students and the class by using practices derived from AST.

Shared concepts that had been created by the class allowed for all individuals to reach a consensus about a concept that ideally the whole class had contributed to. Making class definitions and models allowed for the teacher to elicit students' initial ideas that were later put

together into one cohesive definition or model allowing for students to have an agreed upon concept to decrease confusion. This shows the students that all ideas are important and allows students to reach the concept in the most logical way for them. Furthermore, by making an agreed upon concept, students can use it as a common way of discussing the concept. This allows for better and easier communication between students. This communication is important since science builds upon itself where one concept must be understood to understand a new concept that links to the first. For the students, they needed to understand diffusion to explain osmosis. All initial ideas having value and being able to communicate through shared concepts like definitions and models which are stressed as part of AST also create positive classroom community where students feel comfortable to share their ideas and original thoughts but also to be okay with not knowing the "right" answer all the time and being frustrated. Also, without this comfort the discussions that elicit the initial ideas of students which are integral to AST could not occur so, using AST practices to create positive community allows for AST practices to become more successful as the school year progresses.

Diverse engagement is the last component of positive classroom community. This was seen in the variety of ways that students were able to participate in the classroom. This could have been writing, small group discussions or whole class discussions, which were observed in the classroom. In many cases students have different comfort levels with various methods of participation. A variety of methods allows ideas to be shared by everyone but in a way where they are comfortable. If students are not comfortable in a community their participation is often limited but allowing different methods encourages students to contribute their ideas. Discussions were an area that this was vital for. If students felt unable to participate in the class discussions and that was the only available option, it is much harder for everyone to participate and the ideas

to build on to understand the concept is limited. Since discussions are used to help understand concepts, they need to be structured so all students can participate. AST pedagogy focuses on discussion facilitation particularly at the beginning of the year to model for the students how they are expected to participate. AST practices facilitate the diverse engagement component of positive classroom community by giving many opportunities to engage with classmates and the content. This eliminates frustration and fear that can accompany trying to share ideas within the classroom when students have no choice in how they participate.

For future investigations, analyzing differences between other teachers at different schools who use this method, since AST practices can change depending on the teacher, may be useful. Comparison of different grades in the same school would be another area to further to research. At the school where the observations occurred grades 6-8 are taught by a group of teachers who all use AST further research could compare community in later grades after a few years of experience with AST. The classroom community of the different grades could have many similarities or differences in its formation based on the previous experience of the students.

Chapter 6

Conclusion

Overall AST practices seemed to create a positive classroom community in the observed classroom. AST focuses on student-led learning and pushes for discussion-based practices. Equity is also a main point of the design of the pedagogy and pushes for science to be accessible for all students. These practices observed based on the AST pedagogy helped develop positive classroom community in the three main categories: mutual accountability, shared concepts created by the class, and diverse engagement. All these areas allow students to feel comfortable to share ideas, participate, and discuss concepts with classmates. This is a newer pedagogy that does not have a lot of previous research in its building of classroom community. It is also not as widespread as other pedagogies. This may change in the next few years as this pedagogy aligns more with the Next Generation Science Standards which Pennsylvania updated their science standards to match.

Appendix A

Acorn to Oak Unit Breakdown

Table 1. Acorn to Oak Unit Breakdown

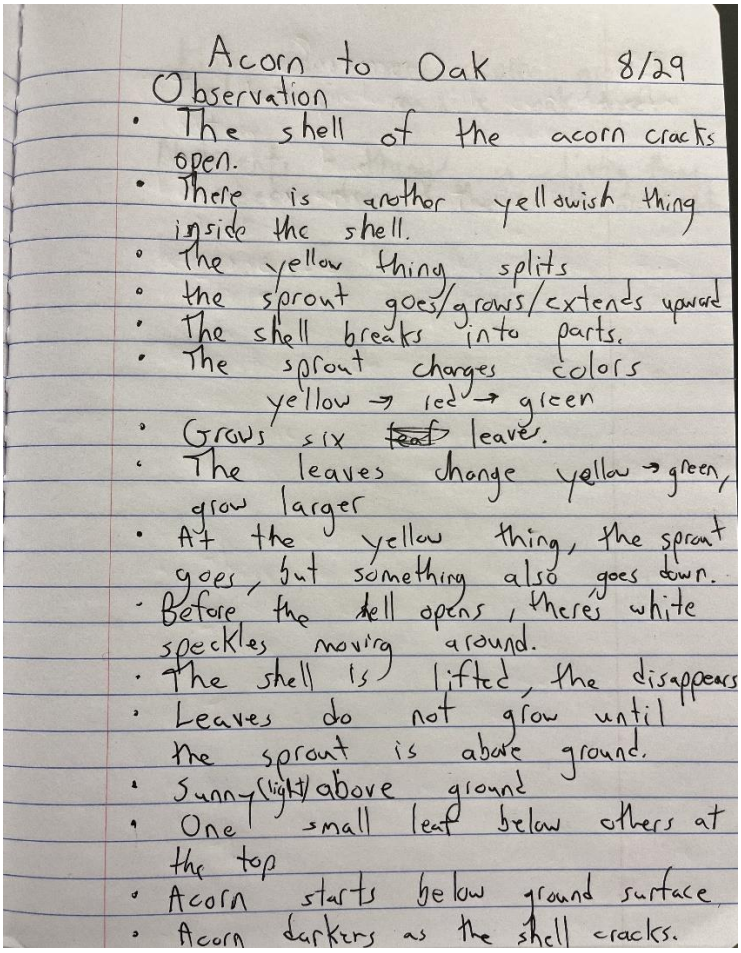
Topic	Investigation	Connection to Acorn to Oak Phenomenon
Intro to Acorn to Oak	Video of an acorn growing into an oak tree	Original observations and having students brainstorm questions
Cells	Looked at different living things under microscopes like pond microorganisms and cheek cells	Understand that living things are made of cells
Diffusion	Food coloring in water, lighting a match were used first. Dyed pink agar cubes showed students how long it took for the dye to come out of different sized cubes	Why cells are so small and nutrient transfer
Osmosis	Shell-less eggs in distilled and salt water, students had to see how the mass changed to figure out if water went in or out of the egg	Nutrient transfer

Mitosis	Looked at onion root tip cells and students had to choose the cells they thought were dividing than make a model based on the pictures	Process of how cells grow and divide to allow the oak to grow
Photosynthesis and Cellular Respiration	Floating leaf disks were placed in different environments like light or no light and CO2 or no CO2 and students watched to see if their disks floated. Also, the cornstarch fireball where cornstarch was lit on fire to show energy was present in the dried plant matter	How cells in the plant get energy to grow
Organelles	Looked at different organelle amounts in different cell types and their function	Understand that the structures in cells help carry out necessary functions like photosynthesis
Nutrients	Two rats one given milk and one given sugar water of equal caloric value to	Nutrients are more than just calories and there are necessary

	milk. The rat that got the milk grew more than the rat that just got the sugar water.	things like minerals that need to come from the environment

Appendix B

Class Journal and Student Work Example



Acorn to Oak 8/29

Observation

- The shell of the acorn cracks open.
- There is another yellowish thing inside the shell.
- The yellow thing splits
- the sprout goes/grows/extends upward
- The shell breaks into parts.
- The sprout changes colors yellow → red → green
- Grows six ~~leaf~~ leaves.
- The leaves change yellow → green, grow larger
- At the yellow thing, the sprout goes, but something also goes down.
- Before the shell opens, theres white speckles moving around.
- The shell is lifted, the disappears
- Leaves do not grow until the sprout is above ground.
- Sunny (light) above ground
- One small leaf below others at the top
- Acorn starts below ground surface
- Acorn darkens as the shell cracks.

Figure 2. Acorn to Oak phenomenon class journal observations

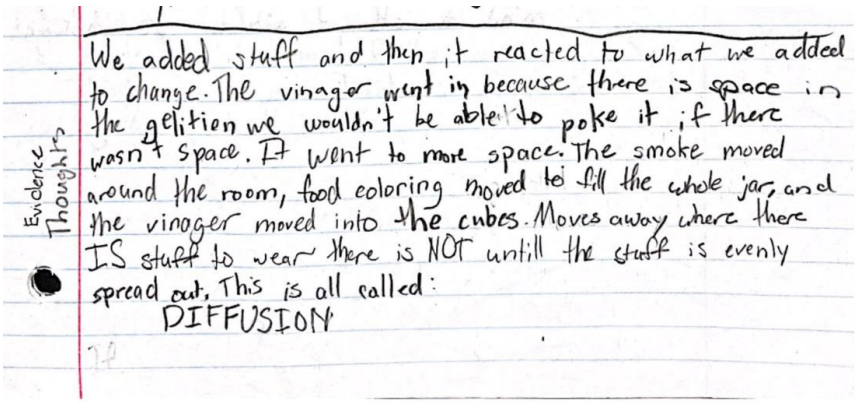


Figure 3. Student evidence for diffusion

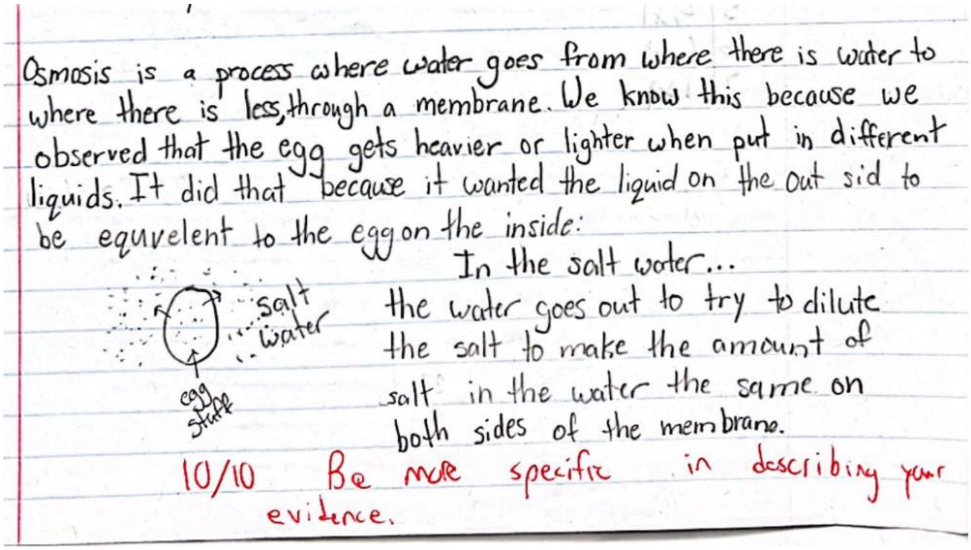


Figure 4. Example Osmosis CER

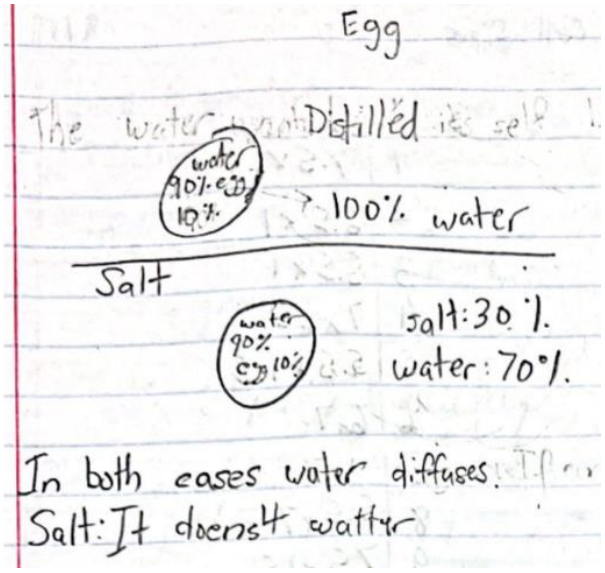


Figure 5. Osmosis Eggs Diagram

1. Ribosomes have a role in the production, use, or storage of proteins by the cells. Hair follicles make the proteins that make up your hair. Hair follicle cells contain a lot of Ribosomes because Ribosomes make the proteins that hair follicle cells need to make up your hair.
2. Mitochondria have a role in storing or using energy that the cell get from their food. Muscle needs energy to move and there is a lot of Mitochondria in musele. The Mitochondria supply the energy to the muscele so that the muscle can move.
3. Lysosomes break unwanted stuff down in the cell. There are a lot of Lysosomes in white blood cells. White blood cells job is to get rid of germs to help the immune system. Lysosomes help the white blood cells do there job.

Figure 6. Example Organelles CER

Appendix C

Next Generation Science Standards (NGSS) for Acorn to Oak

Table 2 contains all the science standards that relate to the Acorn to Oak unit that was observed in the classroom during the 8 weeks and all the standards come directly from the NGSS website (*Home Page: Next generation science standards*).

Table 2. NGSS for Acorn to Oak

Standard Number	Standard Description
MS-LS1-1	Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]
MS-LS1-2	Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

MS-LS1-3	Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]
MS-LS1-6.	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of

	organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

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ACADEMIC VITA

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Summary

Hardworking and reliable student teacher with strong ability in teaching and helping others. Offering Leadership, Communication skills and Empathy. Highly organized, proactive, and punctual with team-oriented mentality.

Education and Training

Bachelor of Science: Secondary Education for Biology, **Minors**: Biology and Psychology
Pennsylvania State University | University Park, PA | Expected in 05/2023

Experience

Learning Assistant | Penn State University - State College, PA| 09/2020 – 12/2021

- Helps create an effective learning environment during large lectures by answering student questions
- Holds office hours for one-on-one tutoring to help students better understand class material
- Gives students tips on studying and preparing for exams
- Help students with individual needs

Seasonal Store Associate | Vera Bradley Factory Outlet – Philadelphia Premium Outlets-Pottstown, PA | 06/2021 – 08/2021, 11/2021- 01/2022, and 05/2022 – 08/2022

- Handled money as well as other forms of payment for over 30 transactions per shift
- Communicated with customers to give best help and experience to those in person as well as over the phone
- Adaptable to whatever was needed during a certain shift
- Maintained the sales floor both during open hours and after closing

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Activities

Schreyer Honors Scholar Peer Mentor

- Time management to allow this to fit with regular coursework and other commitments
- Answer peers' questions about the honors college program
- Support organized events to introduce students to Schreyer in an educational and fun way

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Skills

- Time management and flexibility
- Reliable and trustworthy
- Organizational skills
- Leadership
- Empathy
- Teaching Skills
- Communication skills
- Personable nature
- Working in a team and independently