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High school earth science students evaluating agricultural solutions

Jaclyn Citlali Sanchez Erickson
University of Northern Iowa

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Date: 8/03/2022 Dr. Jeffrey Morgan, Advisor

Date: 8/03/2022 Dr. Alison Beharka, Outside Reader

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Chapter 1

Introduction

The goal of this project was to develop a learning unit for an 9-12 Earth Science class that incorporates agriculture and aligns with NGSS. Is important that the unit aligns with NGSS because The Next Generation Science Standards (NGSS) were adopted by Iowa in 2015, with full implementation by 2020 (Iowa CORE, 2016). The NGSS brings contemporary, relative, and controversial topics to the forefront of the science classroom, such as climate change, evolution, and human impact (Bybee, 2014). The NGSS will, or as predicted by Bybee, 2014, influence curriculum, teacher development and preparation, and assessment (Bybee, 2014).It was a national collaboration to create standards to provide students with the opportunity to learn how to apply knowledge to real-life situations (Hedger, 2018). The framework for NGSS has three dimensions: science and engineering practices, crosscutting concepts, and core ideas (NRC, 2012). These are necessary components of the standards because they involve science practice and application (Bybee, 2014).

It is important that the curriculum created to follow the Next Generation Science Standards includes scientific and engineering practices, crosscutting concepts, and core ideas, allowing students to grow as learners and as scientists to target the whole standard. There is evidence showing that project-based and place-based learning in science helps students learn the material. Information can be found regarding ecology and watersheds, and while the benefits of project-based learning are confirmed for these topics, they need to be expanded into other areas, such as agriculture (Engles, Millers, Squires, Jennewein, & Eitel, 2017). Agriculture education is necessary due to agriculture being a part of the global economy. Students should have a working knowledge of agriculture and career paths in agriculture and natural resources (National Council for Agriculture Education, 2015).

However, limited information is available for NGSS earth science standards in regards to evaluating sustainable agricultural practices and how well students learned the material. In Uganda, Ochan (2012) discusses the success of implementing project based learning with agricultural education, however that project did not use NGSS.

The purpose of this project is to create an authentic project-based learning experience to address an NGSS standard, providing students the opportunity to reflect on how to solve scenarios. The following is the standard that is addressed: ESSS 3-4 Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.

Although students often enjoy projects, I want to ensure that students are having a meaningful learning experience and reaching the learning targets. My research question is: Is project-based learning an effective strategy for students to learn how to evaluate solutions for ecosystem degradation in agriculture?

Chapter 2

Next Generation Science Standards

Meeting the standards

The Next Generation Science Standards (NGSS) started in twenty-six states across the United States, and the performance expectations (PE) are currently implemented throughout Iowa. Lessons and units must be realigned to fit the new benchmarks. The NGSS contains three dimensions: science and engineering practices (SEP), cross-cutting concepts (CCC), and disciplinary core ideas (DCI). The science and engineering practices were written to describe how a scientist engages with science, with the idea that the student will exhibit similar behavior. Crosscutting concepts are challenging to implement; however, they assist the student in applying what they know in a real-world context, making meaningful learning. Disciplinary core ideas are fundamental concepts in science and engineering disciplines (Duncan and Cavera, 2015).

The NGSS has a classroom focus on phenomena, introducing a complex idea to help cultivate deeper understanding through discovery and discussion rather than just a superficial explanation (Pruitt, 2015). The new standards focus on helping the students learn how the world works by encouraging teachers to set up investigations into ecological processes or chemical reactions. As a result, the student is becoming more active in their learning process, helping them develop a stake in their education (Passmore, 2015). The standards were made to help the students make interrelated decisions in this global economy. Scientific literacy is imperative in our world where students will have to understand the issue, whether that issue revolves around natural resources or healthcare (Huff, 2016).

Implementation.

Implementation strategies for NGSS include providing aligned materials for teachers to use as a reference and giving students targeted professional developments such as time,

monitoring progress with implementation and providing support, and providing time to create aligned assessments. By following these strategies, NGSS introduction into the classroom is more effective (Penuel, Harris, DeBarger, 2015). High-quality materials (as determined by the teacher) provide tools to teachers to help students meet performance expectations. This includes lab materials and equipment, resources, access to project-based curriculum, and other types of curriculum (Penual, Harris, DeBarger, 2015). Professional development can include instruction on core ideas in science, providing ideas on student-centered teaching, or how to use and implement the curriculum. Implementing the NGSS requires deliberate planning and creating opportunities for learning, which are needed to help students know the science and how to do science (Penuel, Harris, Debarger, 2015).

Three-dimensional instruction.

The idea of three-dimensional instruction and learning means the teacher is addressing SEP, CCC, and DCI in their teaching. This helps students learn how to apply their learning to real-world problems. Three-dimensional instruction not only teaches content but also has students acting like scientists, exploring themes common across science fields, learning problem solving, and critical thinking skills. All dimensions in the NGSS work together to help students figure out phenomena or solve design problems. To incorporate three-dimensional instruction into the classroom, teachers start by finding phenomena that help with the performance expectation (Kracijik, 2015). Each dimension is needed throughout the curriculum, instruction, and assessment (NRC, 2012).

Implications NGSS has on Science Curriculum.

The NGSS has rigor, helping students become college ready and bound. The standards are available to all students, in order to provide an equal education, in particular for students who

may not have had access to a quality education previously. The standards contain inclusive language promoting diversity. Also, taking into consideration that some districts may not have a large budget, the standards are attainable with low-cost supplies. In addition, the standards were assessed by a committee to avoid stereotypes, and overarching language, and to encourage inclusivity (Lee, Miller, & Januszyk, 2014). The NGSS takes into account not only various demographics but also diverse needs within the classroom (Bybee, 2014). Appendix D of the NGSS goes into depth on how to approach students who have influential factors on their learning, such as historical, social, or language barriers (NRC, 2012).

However, reading about these factors in comparison to teaching students who have these preexisting conditions are two different concepts. Rodriguez encourages teachers to ensure their curriculum is culturally and socially appropriate to impact students' learning (Rodriguez, 2015). This will vary according to the teacher's school and will be an intentional act (Gallard, Mensah, & Pitts, 2014).

Within the NGSS there is a high amount of language that a student would have to learn and skills, meaning teachers will have to be intentional in their instruction to incorporate vocabulary and practice, especially for an English language learner (ELL). To help them achieve this goal, teachers must be intentional in their professional development (Lee, Miller, & Januszyk, 2014).

Curriculum Development for NGSS.

When creating a curriculum using the NGSS, it is necessary to develop material that is rigorous with clear learning objectives using all three dimensions to address the needs of diverse learners (Bybee, 2014). Upon reviewing the performance expectations, learning objectives are

created, then activities are formed to ultimately address the standard. A single standard can have multiple learning objectives, and thus activities (Puttick & Brian, 2017).

When three-dimensional learning is implemented it uses content to help students learn scientific skills. Contrary to traditional teaching, which provides content first then various processing activities, inquiry is encouraged to help learners develop and analyze scenarios. Phenomenon plays a role, by allowing the student to problem solve. The phenomena allows students to build answers to proposed problems using previous knowledge and information used in the unit. This makes the work and learning more meaningful to the student (Penuel & Reiser, 2017).

Inquiry-based instruction

Inquiry learning is allowing the student to come to his or her own conclusion regarding the class material. It pertains to discovery during active learning, whether it is hands-on or not; it can be kinesthetic or mentally processed (Colburn, 2000). One of the benefits of inquiry is that it creates a more "positive impression of science," although Foley & McPhee (2008) did state that students who had textbooks in their classes had positive experiences as well.

Having hands-on activities and inquiry based activities will not necessarily increase a student's understanding, unless the teacher is well prepared, and follows the scope and sequence of the curriculum to increase student understanding (Foley & McPhee, 2008). Roehrig and Luft reported that new science teachers often felt unprepared to lead an inquiry lesson due to a lack of experience and training. Through increased training, science teachers would be able to do inquiry-based instruction effectively (2004).

Students that participated in the inquiry gained valuable research experience, critical thinking skills, and created insightful questions and conclusions on a topic (Magnussen &

Palincsar, 1995). Inquiry-based learning led students to find the "how?" and "why?" behind the content (Schwartz, Lederman, & Lederman, 2008). Those skills will encourage them to act like scientists, create engagement in activities, and begin investigating to determine a solution (Yeh, Jen & Hsu, 2012). When students were taught with inquiry-based instruction in agriculture, favorable attitudes were formed of knowledge and promotion of agricultural careers (Thoron and Burleson, 2014).

Phenomena-based teaching

A phenomena anchors the unit and is presented so that students develop questions relevant to the phenomena to investigate using scientific practices. When choosing a phenomena a teacher needs to ensure that it is explained by the DCI components. In addition, the phenomena needs to have enough depth, so that students form good investigative questions that require more than simple and short answers (Lo et al, 2014). The phenomena should not only generate questions but also relate to the students' lives (Duncan and Cavera, 2017; NGSS Lead States, 2013). Phenomena that are relatable and that align to student interests acts as a catalyst for learning (Penuel, 2017). Using the DCI, CCC, and SEP the phenomena is investigated through various perspectives allowing for evidence based explanations (Duncan and Cavera, 2017; NGSS Lead States, 2013). Learning and understanding how to construct evidence-based explanations of phenomena are required for students to fully understand concepts, because students are learning how to identify the components of systems and how each part in the system is related (Forbes, Zangori, Schwarz 2015). Phenomena, when explained and introduced by the teacher, provides context and has students use core ideas (Penuel, 2017).

5 E Learning Cycle

The 5E model stands for Engage, Explore, Explain, Elaborate, and Evaluate. This is an inquiry style approach meant to encourage a student's natural curiosity and to help them create explanations (Bybee, 2019). The engaging portion of a lesson is meant to pique a student's interest and gauge what they know about a topic. Within the explore section of the lesson students typically will have hands-on experience, and be encouraged to ask further questions on the topic at hand. Afterwards in the explain and elaborate phase, students will explain and connect their understanding. Next is the evaluate portion, where students reflect and show what they know about the content (Gillies & Rafter, 2020).

The NGSS and the 5E model meld well together. When applying the 5E method to the NGSS, it is helpful to view the method as a unit. The model provides the structure for instruction. After identifying the performance expectations, or bundle, the teacher will locate a theme that is used for the unit or lesson. Then, they differentiate between teaching strategies and student learning outcomes for the science and engineering practices (Bybee, 2015). To determine the instructional sequence, an instructor should start with what needs to be integrated - for example cross cutting concepts and scientific practices. Then, they identify activities that will be used to achieve understanding of the concept and/or practice (Van Scotter, Bybee, and Dougherty 2000). The activities and facilitated experiences should be varied and sequenced appropriately integrating the concepts with practices that allow for continued learning for the student (Bybee, 2015).

Understanding by Backwards Design

Understanding by backwards design (UBD) begins by identifying learning outcomes, such as the performance expectations based on the standards. What's great about the backwards design template, in this book, is that it has a section for student friendly objectives. Afterwards,

the teacher determines the types of student evidence to demonstrate their understanding.This is supported throughout the instructional sequence, the end assessment reflects the type of evidence identified. At the end, types of activities are identified and created to lead up to the assessment such as a test or paper (Wiggins and McTighe, 2005).

Assessments are based on performance expectations, and it is important to not forget to include the science and engineering practices in the UBD process (Bybee, 2015). The UBD format allows the teacher to facilitate investigations to meet the NGSS performance expectations, CCC, PE and DCI. This ensures that the lesson stays focused on the standards and permits student inquiry and hands on experiences (Sumrall and Sumrall, 2018).

Project based learning

Our world requires scientific literate individuals who can critically think and solve problems. Students need to have the ability to evaluate and synthesize information to make decisions (Pelligrino & Hilton, 2012). Research supports environments that engage students in natural phenomena using NGSS fundamentals such as science and engineering practices. Project based learning (PBL) is an approach to help students delve deeper into content and skills (Miller & Krajcik, 2019).

Project based learning typically has a driving question that directs learning and exploration for students. Students have to provide a solution for the problem, as part of the resultant product. This type of learning can take time, and teachers take the role as facilitators (Helle, Tynjala & Olkinuora, 2006). Observations for each project can be made and concepts can be scaffolded throughout the school year, so students can make connections on how those ideas are related. PBL can also provide opportunities for connection making outside of the classroom and to the surrounding community (Halvorsen, Duke, Brugar et al, 2012). In a study, students did

a project over local watersheds and collected data over water flow. Their research focused on water quality, water quantity and water use. Prior to going to the field students learned relevant content and lab laboratory skills in addition to looking into issues in the area related to water. Researchers noted that it was beneficial to the engagement of the students to relate their project to their community, enhancing their learning (Forbes, Zangori, & Schwarz, 2015). Through project based learning and relating the topic to the student's location scientific literacy improved (Engels, Squires, Jennewin, & Eitel, 2017).

When structuring project based learning in the classroom, it is important to still do a variety of assessments to provide feedback and assess student understanding (Mergendoller and Thomas, 2001). According to Larmer (2020), one must ensure that rigor is upheld, while following standards, maintaining a student centered project addressing various levels of learning. The gold standard has seven guidelines to help a project stay in line with objectives and maintain rigor.

1. A challenging problem
2. Sustained inquiry
3. Authenticity
4. Student voice and choice
5. Reflection
6. Critique and revision
7. Public product

Agricultural Education

Agricultural education has a place in NGSS, and the NGSS created a potential for it to be taught via inquiry based and project learning methods (Achieve, 2013). In addition, agricultural education provides a lens and framework for learning concepts. It allows students to experience the application side of learning (Meals & Washburn, 2008).

Place-based learning. When there is a lack of agricultural awareness, it is challenging to help students make connections and applications between the classroom and their community (Henry, Talbert, & Morris, 2014). Place-based learning promotes agricultural awareness (Martin, 2006). It helps connect students to the community and focuses on specific locations to assist learning (Woodhoise &Knapp, 2000). When place-based and project-based learning are linked, students have an increase in engagement and appreciation for the content (Engles, Millers, Squires, Jennewein, & Eitel, 2017).

Chapter 3

I teach at a rural school with a population of 364 students, where many of my students' lives center around agriculture. While designing this project I wanted to create an engaging learning opportunity that students were able to relate to. I did an action research project in my Earth Science class addressing the Next Generation Earth Science Standard 3-4, that had students evaluate solutions to solve problems in the ecosystem. The 3D components of the standard are the following: Science and Engineering Practice (SEP) of constructing explanations and designing solutions, Crosscutting concepts of stability and change, and Disciplinary Core Ideas (DCI) of Human Impacts on Earth Systems and Developing Possible Solutions.

Students worked towards achieving the standard by completing a project with a final presentation and reflection for about two weeks. The research question for this project is: Is project-based learning an effective strategy for students to learn how to evaluate solutions for ecosystem degradation in agriculture?

Participants

The demographic of the classes varies between teachers. I had one section of 23 students composed of 1 junior, 8 sophomores, and 14 freshmen. My colleague had two sections of earth science and had 29 students, 4 out of 29 were sophomores. The ages of students ranged from 14 to 17 with a mode age of 14. Only one student was 17 years old, and that was the junior. This class is designed for 9th grade, and Earth Science is only 1 semester at my high school. Since NGSS was implemented and Earth Science is now required to graduate, there is currently a mixture of grade levels in the course trying to ensure all students meet the requirement.
At the high school involved in the study, 55% of students qualify for free and reduced lunch. Male students comprise 53% of the population and 47% are female.

Project Planning

Unpacking the standard

Before designing the project, I used the understanding by design (UBD) template to break down the standard (Appendix A). The understanding box is gathered from the NGSS disciplinary foundation box. I formed "I can…" statements to make the language student-friendly. Essential questions were formed from the disciplinary foundation box and crosscutting concepts. The knowledge box is created using the understanding box, it helps identify facts and vocabulary students need to know. Science and engineering practices for the standards help form the Doing box. The performance expectation helps analyze the type of assessment to provide.

The template helped me identify essential questions, objectives, vocabulary, and crosscutting concepts the project would need to address (McTighe & Brown 2021). The essential questions are as follows:

- How can we reduce the impact of humans on the environment in agricultural systems?

The objectives are as follows:

- I can evaluate solutions that reduce the impacts of human activities on natural systems
- I can identify stakeholders in an ecosystem solution

Project Design and Implementation

In accordance with UBD, while creating the final reflection I knew that the students would have to evaluate scenarios with a problem and provide a solution with support. I created a scenario for every problem and a potential solution that I identified during the design process. When designing the project I thought about common issues that farmers might encounter on their land when cultivating it for agriculture. I wanted a variety of issues so students could choose a solution they were most interested in and create a presentation discussing the pros and cons of

the solution for the problem. Then, they would hear about a multitude of solutions available for the same or different agricultural issues from the other student groups and how to apply the best practices. The problems and solutions are as follows:

Soil Degradation:

- Terraces
- Crop rotation
- No-till vs till farming

Water Pollution:

- Buffer strips
- Cover crops
- Fertilizer choice (manure, anhydrous ammonia, etc...)

Biodiversity Loss:

- Planting systems
- Crop rotation

I used the essential questions and objectives to help create rubric categories that outline how to address each section. The rubric (Appendix C) was used to evaluate students' abilities to address the problem, identify stakeholders, and evaluate the pros and cons of the solution. The participating students include my section of earth science students and two sections of my colleague's earth science students. My coworker and I used the same curriculum to ensure that all our students at the high school received an equal education. Before the project, a parent notification letter was sent home (appendix H) to notify the parent that I would be using the data for this curriculum project.

When we introduced the project, following the Engage of 5E, we asked our students what potential issues could arise in agriculture to engage them by getting ideas flowing. Due to the demographic of the school, which has a large farming community, I knew that some students had ideas and others might have heard of issues, though perhaps they would not be able to fully explain those issues. When the class discussed several options, I asked what solutions are out

there to address those issues. They were able to name a few. Afterward, I introduced the project and noted how some of their solutions were present but there were so many more out there, as well as additional issues that need to be resolved.

After engaging students to help introduce the topic, I presented the essential question of the project and gave them directions (see Appendix B). As a class, we reviewed the rubric. I had students explore the different problems and solutions via the internet to see what interested them the most. I limited the number of the same project to two groups, meaning there were no more than two groups presenting on cover crops. Students only needed their school-assigned Chromebook, access to google slides, and the internet to work on the project. I did encourage the use of a notebook or document to keep track of information such as sources, and any ideas or questions that occurred during their research.

I had students create their own groups due to COVID absences and sports schedules. Some students went into quarantine during this time and later had to give the presentation via Google Meet. Due to my class section being in the afternoon when many sports activity personnel leave, I wanted to make sure that if they had a lone partner left behind he or she was not stuck with doing the work, and it was a collaborative effort. Students had three days to conduct their research and an additional day to practice their presentation before the due date. Presentations occurred over two days.

On the first day before students started their research, we discussed what qualified as a credible source. They have previous knowledge from English class, so the majority had an understanding of what generic qualities to look for: recency, credibility, and ending of the URL. In terms of recency, was the content published within the last few years and not fifty years ago? When talking about credibility, is the information from an individual or institution with

credentials in the area? In regards to URL endings, students brought up .org, .edu and .gov handles. We also discussed the formatting guidelines, because for many in 9th grade this was their first time doing a slideshow for a high school science class. Essentially no crazy color schemes or flying transitions. In addition discussed the use of images, to pick ones that would remind them what to talk about and expand on.

During those three days, we talked about how to use the rubric to set up their presentation. For example, there is a category for pros and cons, so they needed to have 1-2 slides for that category. From there it made it easier for students to research information. I frequently would walk around the room to check in with individuals and groups regarding progress and any questions they might have. During these check-in times, it gave the students an opportunity to engage with me and express frustrations or interest in their topic. Based on those interactions the majority of students were on task and working on finding information.

On the practice day, we reviewed the rubric as a class and I encouraged students to go through the presentation several times. I set up separate spaces ahead of time in open classrooms, lab space, library, and the hallway to give students an opportunity to run through their slide show. For every project day I was consistently and constantly going from group to group to listen for confusion, answer questions, and provide feedback.

For each new problem and solution combination presented, students were encouraged to take notes in addition to paying attention, which the majority of students did both. Their notes should cover each category on the rubric: a description of the problem, how the proposed solution addresses the problem, pros and cons, and stakeholders. If there were two of the same combination presented, I explained that students should expand on their categories if needed. They would need the notes to help them review before completing the final assessment for the

project, the final reflection. The reflection involved two scenarios, one that the student should know an answer to because it was tied to their presentation, and the other about another presentation. The scenarios were fictional, but outlined issues at a farm and required the student to choose an appropriate solution.

I formatted the final reflections which provided two scenarios after project topics were chosen. Each scenario created included a description of the problem and asked the student to figure out an appropriate solution. There were eight different combinations of scenarios for the reflection assignment. For each group, I gave every individual a different scenario combination to decrease the chance of copying and to ensure that each student understood their project and was paying attention to others. Another reason I did this is that not all students completed the reflection on the same day. I had some students out due to sports and others due to COVID quarantine. For each reflection assignment, one scenario was about the topic that the student did and the other was a topic covered within the peer presentations. For example, if a student covered terraces for their presentation, the reflection they completed included a scenario over terraces and the other scenario was over crop rotation (see Appendix D for an example).

Grading

Students underwent skill building and content learning while completing the unit. Every group project situation required communication via presenting the material and writing up their project, problem-solving to address any difficulties they came across, collaboration with fellow group members, and distinguishing between credible and unreliable sources. The content explored in the project helped students learn about agriculture problems and possible solutions to address those problems.

The group project allowed students to collaborate and present their information together. The project was given to three class sections. I had one section, and the other teacher had two sections. We each graded our own classes' projects. During the presentations, we each wrote remarks on the paper and circled what students received on that portion. Students were given a score and feedback in the following categories: Address the Problem, Stakeholders, Pros and Cons, and Communication. Both my colleague and I used the presentation rubric (Appendix C) that outlines the necessary components of each category.

Students were given one grade for the presentation; I combined the content scores and communication scores due to my grading platform. I would have preferred keeping the grades separate, but we were still trying to find the best way to set up the grade book for standards-based grading. For the communication score there were two categories, oral communication and written communication. The two scores were averaged to get the final communication score. The oral communication category focused on presentation skills and the written communication category referenced formatting, writing mechanics, and grammar.

For the purpose of this project and analysis of student learning, I wanted to see if students could evaluate agricultural problems, and I did not want the communication score to affect the content understanding score. The three content categories were averaged to produce the overall content score. My colleague and I graded our class's reflections using the reflection rubric (Appendix E). However, we graded in the same room to reference each other and compare results. The reflection assessed each individual's understanding of their chosen solution and their understanding of other solutions that were presented to them.

The final project rubric was used to determine how well students evaluated the chosen solution for the corresponding ecosystem degradation. There were two categories in the rubric:

solution and explanation. The two categories were averaged to produce the score for each scenario. Then we averaged the two scenario scores to produce a final score. The reflection was graded over a student's analysis of the problem and their choice of an appropriate solution or solutions to address the problem, fully explaining why they chose the solution for the problem.

I found an example of a 4, 3, and a 2 in my reflection stack and provided the examples to my colleague for reference. I did not have an example of a 1. Due to us each grading our own class periods, if we had any questions we made sure to consult each other before giving the final scores. For example, did the student elaborate enough on the "explanation" section of the reflection.

Project Results

At Chariton High School, we are moving towards standards-based grading. Teachers are asked to create rubrics for major assignments. The rubrics employ four common categories that all teachers use: Advanced (4), Proficient (3), Progressing (2), and Beginning (1). Teachers can assign scores between categories, such as 2.5. If the student is assigned a 0.5 or 0, it is considered a standard not met, and insufficient understanding. The project was assigned in three class sections by two instructors, we each scored our students during class time, then met and reviewed any questionable notes that we took during the presentations together. For example, we discussed what it meant to expand on a pro/con. When grading the presentations we scored each category, because they each had their own row in the rubric, then averaged the score. In my classroom, 3 out of 9 groups were marked progressing. 4 out of 10 groups were marked progressing in the other teacher's class sections.

When students were presenting, I scored the rubrics and wrote comments. If a group received a 1 for that category, they either only identified the minimum number of stakeholders or

pros/cons and did no discussion, or had some errors. For example, an error would be identifying an incorrect stakeholder. In the case of one group, they scored a 1 due to only listing stakeholders not expanding on why they had a stake in the issue. Students who scored a 2 gave a general overview of the category and gave minimal discussion. A 3 was received when they addressed the requirements and either lacked discussion or made minor errors; for example, providing 3 pros and 3 cons with minimal expansion. A 4 was given when they met the requirements and made further connections. In my classroom, the average score for the presentation of the main categories was 3.14, with 9 groups. In the other teacher's classroom, it was 3.09, with 10 groups. The standard deviation for my class was 0.829 and for the other class 0.793. The standard deviations are large and the ranges of scores have significant overlap. For the purpose of this project, the scores for this data are based on the three categories of the project: address the problem, stakeholders, and pros & cons. A complete data table of category, final presentation, and reflection scores are located in Appendix F and G.

One of the student groups that studied the use of buffer strips to address water pollution did a great job addressing stakeholders. They identified four stakeholders: farmers (owners), wildlife, consumers, and renters. For each stakeholder, they discussed how they were affected by the problem and how the solution would help them. This group received a 4 in this category. Another group, addressing fertilizer choice, received a 2 in this category because they listed stakeholders but minimally discussed the stake each individual had in the issue at hand.

One group that presented cover crops received a 4 in Address Problem. They identified the problem the cover crops were helping as water pollution. They outlined what caused the water pollution such as runoff of fertilizer and discussed further how that could impact others, then discussed how cover crops would help. The group that covered crop rotations scored a 2,

they defined the term biodiversity loss and only briefly discussed two causes. They lacked information on how those two causes are related to biodiversity.

For the Pros and Cons category, one group did a good job discussing the pros and cons they listed, but only had two and did not connect them to the problem, and were scored a 2. In contrast, a fertilizer choice group that received a 4 had three pros and three cons and discussed each of them. In addition, they expanded on cost-effectiveness by comparing the optimal fertilizers.

For both classrooms, the reflection scores were higher than the presentation scores. I had 17 out of 23 students complete the final reflection for my earth science section. Some students forgot to make-up the reflection due to sports, while others were sick. When grading the reflections I followed the rubric which was divided into two categories: solution and explanation. The scores were averaged together, meaning if they received a 3 in solution by a 4 in explanation then they had a final score of 3.5. I looked for the accuracy of the solution, their description of the solution, and the connection between why they picked the solution and how it could help address the problem. The score for each scenario was then averaged together for the final score. For example, if scenario one received a 2 and scenario two received a 3 the final score was 2.5. In my classroom, the average reflection score was 3.26 (Appendix F), which included 17 out of 23 students. The other teacher's students' average was 2.52 (Appendix G) of 25 students out of 29. The standard deviation for the reflection for my class was 0.752 and for the other teacher, it was 1.229.There is some overlap, even though averages are different. Students on average scored proficient in my classroom, meaning that they scored sufficient understanding and application of the standard, and were able to evaluate the problem in the agricultural system and think of an appropriate solution. The other teacher's average score would be considered almost proficient.

The following is an excerpt from a student who received a 2 on their response:

> *Scenario:* A landowner, named Tucker, noticed that in a bordering stream there is increased algae growth impacting the fish population. He also had a soil test done on his cropland and found that there were increased levels of potassium. What would you recommend that he implement? Explain.
>
> *Answer*: The reason algae are growing is from the pesticides that the farmer is using. There is a natural base pesticide that is water based so it dissolves in water but is more expensive. Another reason algae might be growing and affecting the fish population is that the pesticides are harmful to the environment and have harmful chemicals and it's cheap for farmers.

The student received a 2 because they kept using the wrong word. The correct word is fertilizer. They did connect the reason algae was growing and had accurate reasons to support their choice. There are minor errors indicating the pesticide (rather fertilizer) is cheap, however, it is not clarified which type of chemical that is referenced as the water base or regular. If the student used the word fertilizer correctly, I would have given the student a 3.

The following is an excerpt from a student who received a 4:

> *Scenario*: Trevor is a farmer who has some land, he would like to start planting crops in this area. However, he needs help identifying the best manner to plant his crops. The land is steep, and he is concerned about surface runoff and soil erosion if he doesn't implement a solution to reduce the impact on the environment. Help him decide the best solution to do, and explain why you chose it.

Answer: I think that the option most benefitting Trevor would be terraces. He mentioned how the land was already pretty steep, so this solution wouldn't be that hard to achieve. These terraces would reduce runoff and soil erosion like he wants by slowing down the water and sediment traveling down one level at a time. If we thought about other solutions, such as buffer strips we would notice that although these may reduce runoff with the way Trevor's land is set up, it couldn't reduce soil erosion especially since the land is steep. These are all reasons I believe that terraces are the best option.

This student received a 4 because they named an accurate solution and discussed why it would work for the scenario by explaining how the solution works. In addition, they compared it to another solution showing their understanding.

Chapter 4

Analysis of Results

After examining the average scores for the students, I was pleased to see that students overall did well on the project, scoring in the proficient column. The score indicates to me that they understood and grasped the standard. When reviewing the combined score of the presentation and reflection, the average scores were 3.15 for my section and 3.03 for my colleague's two sections, meaning both teachers had classes that scored proficient on average. As a whole, students were able to achieve the learning objective for the project to target the standard. Knowing this helps the teacher understand that the project has enough integrated support and directions to help students do well. This ensures that the learning objective is attainable.

When reviewing each criterion for my class it appears that 'identifying and discussing stakeholders' was the weakest section for students with an average score of 2.89, while my colleague's sections had an average of 2.9. This number lies in the progressing column, though close to proficient. The standard deviation of 1.167 in my section and 0.737 in my colleague's section, shows that my data was slightly more spread out. Looking at the data (Appendix F), I scored one out of nine groups a 1, three groups out of nine scored a 2, one out of nine groups scored a 3, and four out of nine groups scored a 4. The other teacher scored their groups from 2 to 4, there were no 1s. The group that received a 1 in stakeholder unfortunately a group member was gone for a day. I did encourage collaboration when attaining and synthesizing information; if this group member was in charge of this portion it may be why this section was lower.

In one project the students' agricultural problem was water pollution and their solution was changing the fertilizer so it has a less negative impact. The students identified stakeholders

as the farmer, consumers of the food, and wildlife. They did not go into any detail as to why the stakeholders had a stake in the issue. Before the unit students read an article on carbon sequestration where they identified stakeholders, but they did not identify or discuss what the individual's stake was due to time constraints. Due to minimal discussion of the stakeholders, this group received a 2.

Upon further study of the student's rubrics and my notes on their assessments, students were able to identify stakeholders but not why the stakeholders had a stake in the problem. Perhaps I could integrate stakeholders and their roles further in earlier assignments and practices, diving into a discussion on what it means to be a stakeholder and why someone would be. If able, it would be beneficial to integrate this concept in prior learning to help students expand on this section in the project.

For the category Address the Problem the average was 3.22 in my section and 3.4 in my colleagues' classes. These numbers show proficiency, with the ability to discuss how agricultural practices affect the land in detail. Students who scored well typically described the problem first and then discussed the implication on the environment. The standard deviation of 0.516 for my colleague's sections and 0.833 for my section, shows the range is small and the two overlap, meaning there is little difference between the sections. I scored two out of nine groups with a 2, other groups scored either a 3 or a 4. The other teacher only had 3s and 4s for this category. When addressing the problem, the groups that had the score progressing lacked detail.

In the category Pros and Cons, the average of 3.33 in my class shows proficiency and in my colleagues, it is 2.8 almost proficient. Groups that scored proficient or advanced met the required amount of pros and cons, and in addition expanded on why the reason is a pro or con. The difference in detail determined whether the group received a 3 or 4 in that category. The

standard deviation of 0.829 in my class and 1.317 in my colleague's show that both of her sections had a wider spread of scores. For my colleague, 5 out of 10 groups received a 4, and the other groups either a 1 or 2. Reviewing her notes, these groups lacked detail and/or did not meet the required amount of pros and cons. Perhaps during a previous activity, we could address the pros and cons as well as help them increase detail in their descriptions to help students earn a proficient score.

For the reflection, the average in my class was 3.26 and in the other sections was 2.52. This shows that my class scored slightly above proficient and the other classes are almost proficient. The standard deviation in my class was 0.752 and in my colleague's class 1.23. This shows that my colleague's classes had a wider spread of scores. Observing the data table my range of scores is 2-4, and the other two sections are 0-4. We discussed the differences in class demographics, which could contribute to this. One reason was perhaps the students did not take quality notes to review later. Another reason is that some students in our classes have difficulty with reading fluency and writing skills. In my section, I had very few IEPs in addition to having sophomores and a junior who have had me as a teacher before and were used to evaluating scenarios and data in previous classes. They were trained as 9th graders to provide a claim with evidence and reasoning. In comparison, my colleague had quite a bit more IEPs and student's who needed extra assistance. This year we had 35 ninth-grade students out of roughly 120 come in with an IEP. We did do the appropriate modifications that were required, but some of them had a hard time with the writing portion.

For the reflection data, I did not include students in the analysis who did not participate in the reflection because it would not reflect their understanding of the material. 5 students did not do the reflection in my classroom and 4 students did not take it in my colleague's classroom.

Students were absent that day either due to sickness or sports and did not make up the reflection later. Another possibility is that perhaps these students were satisfied with their final grade and did not feel the need to complete the reflection.

We scored students on their oral and written presentation skills. My section's score was 2.7 and my colleague's sections were 2.8, very close with room for improvement. I think providing a practice day was beneficial, as many freshmen had not had many opportunities to present as they were early in their high school careers. What might improve their skill is doing a mock presentation to another group and having that group provide feedback based on the rubric. I would model this first and have students provide their feedback to me to help them understand the rubric.

Overall, at the initial glance of my data it appears that the project was moderately successful. The averages that were progressing were close to proficient, and other averages were proficient. However, when looking at the data within the category it appeared that about 50% of students were proficient or advanced, and the others were progressing and few beginning with their scores. I feel that most of the project was successful, the data shows me that students who received a progressing did not expand on explanations. This is a skill that we do need to work on. If I had taught this in the spring semester, I would be interested to find out if this was addressed.

Changes to the project

As I think about changes I would make to the project for future use, I would require a minimum number of stakeholders to be discussed to give students more guidance. Hopefully, this would encourage students to expand their research and include detail in their presentations regarding the stakeholders.

In addition, I would make changes to the advanced column on the reflection rubric. While grading, I was impressed by students who not only chose the correct answer but also provided 1-2 supporting solutions. I did not take that into consideration when creating the advanced column. Next time, I would also include a rubric for each scenario for ease of reading and feedback. I color-coded this time and tried to ensure it was clear which score went with the scenario. It wasn't hard to do, but I did have a few clarifying questions from students on my comments as to which scenario it belonged.

To help students with presentation skills, I would not only require a presentation grade, but also to have them practice in front of other groups and then switch.

A great extension to this project would include a field trip to a farm that utilizes one or more of the solutions to reduce impacts on soil degradation, water pollution, or biodiversity loss. Then, they could ask the farmer what pros and cons he or she has experienced with the solution(s). If I did this field trip, I would probably change the order of topics according to the semester. This project was done in December, it was not an ideal time to visit a farm due to the cold, but perhaps the farmer could visit the classroom as a speaker. For the fall semester, I would do the project earlier next time, and in the spring semester, I would keep the same progression of curriculum. If I kept the same sequence of learning, then students would go on a field trip. This project does need other activities, related or not, to practice skills.

Reflections

Reflection in regards to the gold standard

According to Larmer (2020), any project designed should meet the following guidelines: a challenging problem, sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and a public product When reviewing the Gold Standard, for the project I

designed, I concluded it meets the majority of the guidelines. For the criteria challenging problem, there were three problems that needed to be addressed with solutions. Students had to familiarize themselves with the issue at hand. For the guideline student choice, students were allowed to pick the problem they wanted to address and from there a solution that they were going to research. Students created an authentic project different from other groups, having to choose relevant and applicable information. Students were given an opportunity for feedback throughout, and a day to practice and review their project prior to providing a presentation of their findings. The project did not meet the revision criteria for the gold standard. In my classroom, students can choose to revise and correct errors to enhance their learning and provide an opportunity to increase their score. This opportunity was not taken advantage of for this project, and it was also not part of the project which is the requirement for the gold standard.

Reflection in regards to Masters classes and Understanding by Backwards Design

I took a class, *Developing Science Curricula*, from Dr. Jody Stone that had us delve into the concept of standards-based grading and using understanding by backwards design to create a curriculum. It was my first introduction to standards-based grading but allowed me to have context when my school started to transition over. Before that, I was only exposed to traditional grading. Standards-based grading helps focus on the assessment for the standard and not other factors. When I learned about understanding by backwards design, it changed by planning for my classes by starting with what the assessment should be. This helped me focus on what the standard needed students to not only understand but also do.

For this project, I used the UBD template to help figure out what I needed the students to do, which was to evaluate solutions for the agricultural problem. Hence, I formatted the reflections with two scenarios, so students had an opportunity to analyze the scenario and

problem presented, and then evaluate what type of solution would work the best. I also wanted to make sure that each individual was contributing to the group project, which is why the reflection was for everyone to do. Keeping that in mind, they needed to learn about the issues and potential solutions along the way. I created the project to help students focus and delve into their chosen solution and agricultural problem and later present it, to help them learn.

When I took Dr. Chad Hienzel's *Geology in Iowa* course, it helped me see our state in a different way. We went to farms, quarries, and fossil areas. I wanted my students to get a glimpse of that so when appropriate I would try to help bring parts of Iowa into my teaching, so we can have a better understanding of where we live. For my project, I gave students real world scenarios that connected to the local area and to some of their lives. I could further incorporate field trips to help enrich and extend this experience.

Reflection on Inquiry-based instruction

According to Colburn (2000), inquiry is not only physical but can be mentally processed as well. Though this project did not get my students moving around, like in a lab situation, it did provide opportunities for research and processing information to answer the objectives. The problem at hand for students to pursue was addressing soil degradation, water pollution, and biodiversity loss. They had to research and peruse information to find why soil degradation, water pollution, or biodiversity is a problem and discuss how their chosen solution would address it. This style of inquiry-based instruction helps students form critical thinking and research skills (Magnussen & Palinscar, 1995).

Reflection on Phenomena-based teaching

This project does not fulfill the aspect of phenomena-based teaching. Though it is relatable to students' lives, it does not provide opportunities to generate questions and then

pursue the answer to those questions (Penuel, 2017). For this style of project, I would not introduce a phenomenon. If this project was more styled with, for example, examining the problem of soil erosion and showing students what is happening, then allowing them time to develop questions on how and why it might be happening would be more appropriate. This project is taking a wider scope, introducing a multitude of possible issues and allowing opportunities for evaluation of different scenarios at the end.

Reflection on 5E learning Structure

I used the 5E structure to help create the project introduction and outline. In the first step, Engage, I started a discussion with my students and asked them about potential issues that could arise in agriculture, then we brainstormed possible solutions. To address Explore, I had students research solutions listed in the directions that pique their interests. The project addressed Explain when it had students describe the problem and solution. The next step Elaborate had students look into the pros and cons of the solution along with stakeholders. Students had to evaluate scenarios at the end of the project in their reflection.Though the project did meet most criteria, it does not address the Extend step of the 5E method.

Reflection on implications of the project for teachers, science education, and NGSS

This was the first time I taught earth science and subsequently the first time I taught this standard ESSS 3-4 as a project. Because this was a group project, I thought it useful to also have an individual component to ensure I was assessing all my students' individual understanding. I felt that this also helped students stay on task and engage in their learning.

Reviewing the projects and observing the engagement of students, I think the project went well. It needs improvement in the areas I listed previously. If I continue to use it in my

classes, I will have to keep it updated with new techniques and solutions, such as terraces to reduce erosion and water runoff on steep land.

Some students in my classroom had agricultural connections; either they knew someone with a farm or had a family farm. I felt this provided a moment for those students to shine and share their knowledge during the initial discussion of what agricultural solutions are present to address human impacts. For those students who did not have agricultural connections, I tried to provide examples to promote connection, such as fertilizer on the lawn. For some fertilizer, you can't let your pets out for 24 hours, meaning if this fertilizer entered streams, that might negatively impact aquatic plants and animals. It was encouraging to see students acknowledge that there were problems such as runoff causing fertilizer and other pollutants to enter bodies of water. In our school community, the local water source often has problems, so some students realized there might be a connection, which was a fun discussion to have during the research portion.

The project did address the "evaluate" description in the targeted standard: ESSS 3-4 Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems. Students had to evaluate the solution and how it reduced human impact on one of the problems: soil degradation, water pollution, or biodiversity loss. Students did not refine a solution. However, due to the clarifier "or", I felt that this was acceptable.

Regarding addressing the SEP of constructing explanations and designing solutions, this project did have students form an explanation of how the solution addressed the problem. It did not provide an opportunity to design.

The DCI for this project was Human Impacts on Earth Systems and Developing Possible Solutions. This project required students to discuss how the problems occurred and had them

research a solution. In the context of the standard, students should look at the constraints of a solution, some of which are hard to find. For example, finding the accurate cost of some solutions is difficult. There were vague descriptions for some, and words like “expensive” and “cost-effective” were used.

For Cross-Cutting Concepts, the project did help students discuss the influence of the solutions and how effective the solutions were.

There are relatively few resources regarding ESSS 3-4 for Earth Science teachers to use in their classrooms (Engels 2017). As a result, I created this project and I hope other teachers can use it. In terms of feasibility at other schools, the project can be taught and adapted to other classrooms. In certain areas of the country, some solutions are more prevalent than others, just like in Iowa. Iowa is not uniform in geography, as some areas are flatter than others or have far more hills. Keeping that in mind, I would provide more guidance about lesser known solutions, depending on the techniques used in the surrounding community. For example, if the community is near bodies of water I would emphasize surface runoff in particular because what we do can implicate our local watershed.

If teachers do use this resource, I suggest reviewing research skills if students did not receive instruction in other classes such as ELA. This project was geared toward 9th graders, so they received guidance on how to format it. I did need to give a quick tutorial to some students on how to create a slideshow. If teachers use this for higher grade levels, I would recommend they let students decide how to do that,and perhaps even let them choose the format like a slideshow or a paper. I would also recommend considering what happens if a group member is gone: do they get an extension, wait till the individual is back, or does the group present anyway?

Reflection on personal professional implication

Creating this curriculum component, not only for my classroom but for my degree requirements, has immersed me in the understanding of NGSS and its implications for developing students who are science-minded when looking at the world. My master's classes and the University of Northern Iowa teaching program have prepared me to understand how to do that. The curriculum development had me delve into utilizing understanding by backward design and how to create a project and an assessment that is aligned with the standard. For this project, I chose to address the standard by implementing PBL based on the UBD.

After doing the research project and analyzing the data, I feel that I am a better teacher. It has helped me ask myself, what does the curriculum look like according to the standard, and are my students engaged in what we are learning as a class? As to my future professional growth, I am taking a break from teaching to be home with my two children, but hope to return to teaching in schools again. I plan to continue taking classes to keep my teaching credentials current. If and when I return to the classroom I plan on implementing this curriculum with the changes I discussed in my paper, given I teach the course. It does need some changes, and further scaffolding to help students become more successful, but students were engaged in the project and did learn about agricultural problems and solutions.

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Appendix A: Understanding by backwards design template

Solutions for Ecosystems

<table>
<tr><td colspan="2">Standard
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ESS3-4
Clarification Statement and Assessment Boundary

Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).</td></tr>
<tr><td>Understanding
I can…
… evaluate solutions that reduce impacts of human activities on natural systems
… identify stakeholders in an ecosystem solution</td><td>Essential Question

How can we reduce the impact of humans on the environment in agricultural systems?

When farming, how can we reduce our impact on the environment?</td></tr>
<tr><td>Knowledge: the student will know…
… humans can create technology that reduces pollution and waste
… humans can help prevent ecosystem degradation
… to consider restraints when designing solutions
…. How to evaluate solution for impacts people and environments

Vocabulary:
- Ecosystem degradation
- Stakeholders
- Biodiversity</td><td>Doing: the student will do….

Identify stakeholders in a solution that reduces human impacts

Feedback analysis if a solution will stabilize or destabilize systems</td></tr>
<tr><td colspan="2">Assessment:</td></tr>
</table>

Summative assessment (presentation): the content of the presentation is graded and there is a communication score that is separate to address science and engineering standards.
Final reflection: students analyze final scenario and provide an appropriate solution

Appendix B: Project Outline

Assessment Outline

Background: Agriculture is a necessary component in our lives from the food on our table to the fuel in our cars. Although agriculture is needed, it has negative effects on our environment. Your job is to fund a solution to address the following problems that are coming to head in each scenario outlined below. Choose one scenario to research and evaluate the merit of the solution(s). No more than 3 groups per project idea.

Objective: Evaluate solutions to minimize the effects of agriculture on the environment.

Criteria: Below is a list of criteria that you need to include in your presentation.

- Discuss why the the problem is happening
- Identify stakeholders in the scenario
- Discuss pros and cons of each solution
    - Mentions the cost savings/effectiveness of your solution
- Sources: minimum of 2 credible sources
- Format
    - Google Slideshow
    - Relevant images on each slide (ex. Picture or a graph)
    - Appropriate color scheme

Project ideas:

Soil Degradation:

- Terraces
- Crop rotation
- No till vs till farming
- Your choice

Water Pollution:

- Buffer strips
- Cover crops
- Fertilizer choice (manure, anhydrous ammonia, etc...)
- Your choice

Biodiversity Loss:

- Planting systems
- Crop rotation
- Your choice

Reflection:

- Discuss your selected solution(s) you are in favor of using to address the problems.
    - Given in class, you will be provided with 2 scenarios to address. (individually)

Appendix C: Group Project Rubric

Standard	Criteria	Advanced	Proficient	Progressing	Basic
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems **ESSS 3-4**	**Address Problem**	Strongly discusses how agricultural practices affect the land with details	Discusses how agricultural practices affect the land with details	Discusses how agricultural practices affect the land, general overview	Minimal discussion on how agricultural practices affect the land.
	Stakeholders	Identifies all the stakeholders and what kind of stake they have in the scenario	Identifies all the stakeholders and what kind of stake they have in the scenario *minor errors	Identifies stakeholders and minimally discusses their stakes Or errors/omissions	Identifies stakeholders Or errors/omissions
	Pros and Cons	Discusses a minimum of 3 pros/cons of the solution. Connecting the solution to the problem.	Discusses 3 or less of each pro/con for the solution connecting it to the problem	Discusses less than 3 pro/con of each solutions	Minimal discussion over pros and cons
	Reflection	Analyzes the ecosystem degradation problem and chooses an appropriate solution. Explains why they chose the solution giving details on how the solution will address the problem	Analyzes the ecosystem degradation problem and chooses an appropriate solution. Explains why they chose the solution giving details on how the solution will address the problem. *missing detail or has a minor error	Chooses a solution for the ecosystem problem and briefly discusses why they chose the solution. Barely addresses how the solution solves the problem. *general overview	Chooses a solution and briefly discusses why they chose the solution Or how the solution solves the problem. *omissions/errors
Communication	**Oral**	**Oral:** Effectively expresses thoughts and ideas in interpersonal and group scenarios with a variety of audiences. Does not look at slide, is rehearsed, appears comfortable with information Maintains eye contact throughout presentation	**Oral:** Effectively expresses thoughts and ideas in interpersonal and group scenarios Occasionally (2-3 times) reads off or references slide, somewhat rehearsed,understands and knows most information. Eye contact majority of the time	**Oral:** Expresses thoughts and ideas in interpersonal and group scenarios to limited audiences. References or reads off slides more then 3X, does not understand parts of their topic. Minimal eye contact.	**Oral:** Has limited ability to express thoughts and ideas Not rehearsed, reads off slides entire time, does not know topic. Does not maintain eye contact..
	Written	**Written:** Significantly and effectively delivers the content's purpose to personal and professional audiences with proper grammar, mechanics, and format. Follows 5X5 100%	**Written:** Effectively delivers the content's purpose to an audience with proper grammar, mechanics, and format. Follows 5X5 75%	**Written:** Delivers a purpose to an audience with limited errors in grammar, mechanics, and format. Follows 5X5 50%	**Written:** Attempts to deliver a purpose to a limited audience with multiple errors in grammar, mechanics, and format. Follows 5X5 less 25% or not at all.

Appendix D: Final Reflection example

FINAL REFLECTION Name_____

Directions:Read the scenario below and answer the question. Choose the appropriate solution, discuss why you chose the solution and how it addresses the problem.

Scenario:

Tony notices that some topsoil is disappearing after he harvested his crop field due to surface runoff. Topsoil has many important nutrients needed for a successful crop. He wants to increase microbial biodiversity and nutrients in the soil. It is currently the off season, what is something that Tony can do to help preserve his land for next season? Explain your answer.

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Scenario:

A landowner, named Tucker, noticed that in a bordering stream there is increased algae growth impacting the fish population. He also had a soil test done on his crop land and found that there were increased levels of potassium. What would you recommend that he implement? Explain.

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Appendix E: Reflection Rubric

Standard	Advanced	Proficient	Progressing	Basic
Solution	Chooses an appropriate solution and describes the solution	Chooses an appropriate solution and provides a brief description. *missing detail or has a minor error	Chooses a solution for the ecosystem problem, with a vague description	Chooses a solution, does not provide a description
Explanation	Explains why they chose the solution giving details on how the solution will address the problem	Explains why they chose the solution giving details on how the solution will address the problem. *missing detail or has a minor error	Briefly discusses why they chose the solution. Somewhat addresses how the solution solves the problem. *general overview	Vaguely discusses how the solution solves the problem. *omissions/errors

Appendix F: Erickson Class Data

Erickson Groups	Address problem	Stakeholder	Pros and cons	Final project score of the 3 categories	Oral and written Presentation Score	Reflection
A	4	4	4	4	2.5	4
						3.5
B	3	4	3.5	3.5	3	4
						4
						4
C	3	1	3	2.3	3	2.5
						3.5
D	3	2	4	3	4	3.5
						2
F	4	4	2	3.3	2	3.5
					X	
G	2	2	3.5	2.5	3	3
						4
H	4	3	2	3	2	2
						3
						3
I	2	2	4	2.6	2	2
J	4	4	4	4	3	4
Standard deviation	0.83	1.16	0.82	0.609	0.66	0.75
Average	3.2	2.8	3.3	3.1	2.7	3.2

Appendix G: Colleague Class Data

Groups	Address problem	Stakeholder	Pros and cons	Final project score of the 3 categories	Oral and written Presentation Score	Reflection
K	3	2	1	2	2.5	4
						3
						3
L	3	3	2	2.6	2.5	3
						0
						1
						2
M	3	2	2	2.33	2.5	3.5
						1
						1
N	3	2	1	2	2.5	3
						2.5
						2.5
O	4	3	4	3.6	3	3.5
						2.5
P	4	4	4	4	3	2.5
						3.5
						1
Q	4	3	4	3.6	3	3.5
						4
R	4	4	4	4	3	4
						0
						2.5
S	3	3	4	3.3	3	3.5
						1.5
T	3	3	2	2.6	3	4
						4
						2.5
Standard Deviation	0.51	0.73	1.31	0.79	0.25	1.22
average	3.4	2.9	2.8	3.03	2.8	2.5

Appendix H: IRB Notification Letter

Hello Parent/Guardian,

I am your child's Earth Science teacher and am currently pursuing my master's degree in Science Education through the University of Northern Iowa. I want to notify you of a research study that I am working to examine student learning in my class, there is no monetary benefit involved except to help improve student learning.

In an upcoming unit, students will evaluate agricultural solutions to solve problems in the ecosystem, for example soil erosion. Students will make a presentation to show their understanding of the solution either by themself or with a partner, and each presentation will evaluate a different solution. Then they will write a final reflection, to tell me their thoughts on what solution(s) should be used to address the problem in the ecosystem.

For my study, I will examine student performance on their presentation and reflection paper to help me decide whether or not project-based learning is an effective way of addressing this content. The unit is required as part of my course and meets Iowa Science Standards, however participation in the research study is voluntary and contains minimal to no risk. If you do not wish your child to be involved, please notify me via email or written note.

For students who do participate, their identity will be kept confidential and no identifiers will be used when discussing them in my research paper. For example, instead of John Smith I will use Student A.

If you have any questions please do not hesitate to contact me, my advisor or UNI's Institutional Review Board administrator.

Jaclyn Erickson: Jaclyn.erickson@chariton.k12.ia.us (teacher)
Jeff Morgan: Jeff.Morgan@UNI.edu (Faculty advisor)
Rebecca Rinehart: rebecca.rinehart@uni.edu (IRB administrator, they evaluate the study to make sure students are not put at risk)

Thank you for your time,
Jaclyn Erickson