I. Title of Project

Integrating STEM into Everyday Practice: 3Ds to 5Es

II. Curriculum Topic, School Name(s), Number of Educators, Grade Level(s)

Thales Academy is a private day school that serves approximately 3000 students over 8 campuses in North Carolina. The school is a 1:1 iPad school in grades 6th-12th and the elementary schools are outfitted with iPad carts and technology labs.

The school provides direct instruction in grade PK-5 which employs rapid pacing, grouping by skill level, and teaching to mastery so teachers can lead class more efficiently and students can learn more effectively. Classical education is used in the junior high and high school levels at Thales Academy; this combines an in-depth study of primary texts with Latin, logic, rhetoric, and philosophy to develop critical thinkers who are eager to investigate the world around them. The Socratic Method of discussion is also used, engaging students in deep and probing dialogue by asking and answering questions until objective truth is reached. Teachers have a lot of autonomy in their classrooms as Thales uses a standards-based model. This allows teachers to use their creative expertise to create and tailor the curriculum to meet the needs of their students. The 1:1 iPad integration allows for interaction and helps teachers to build lessons beyond the walls of their classroom.

The participants from Thales Academy included one elementary teacher, four middle school math and science teachers, three high school math and science teachers and one high school Trivium teacher. Additionally, three retired public school teachers and two high school science teachers from local high schools were in attendance.

A second professional development was tailored specifically for elementary teachers and held at a local public Title I school Bunn Elementary. In attendance, were six elementary teachers and one retired school teacher. Two were first-grade teachers, three were fourth-grade teachers and one was a fifth-grade teacher.

Due to the vast distances between campuses, I knew it would be hard to get other campuses involved. So I chose to implement training that was not subject specific. Many math principals were also incorporated showing how the three dimensions can lead to NGSS and CCSS integration of a 5E model. Additionally, in the elementary training, I attempted to help them realize the reading and social studies elements that could be included.

A total of twenty teachers participated in the two professional developments offered.

III. Standards Addressed

Middle School/High School (First Professional Development):

Next Generation Science Standards:

Disciplinary Core Ideas:

MS-LS3 Heredity: Inheritance and Variation of Traits:

Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)

HS-LS3 Heredity: Inheritance and Variation of Traits

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

LS3.B: Variation of Traits: Environmental factors also affect the expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

Crosscutting Concepts:

Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3- 2)

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)

Scale, Proportion, and Quantity: Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-LS3-3)

Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)

Science and Engineering Practices:

Asking Questions and Defining Problems:

Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)

Analyzing and Interpreting Data:

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS3-3)

Developing and Using Models:

Develop and use a model to describe phenomena. (MS-LS1-2)

Develop a model to describe unobservable mechanisms. (MS-LS1-7)

Planning and Carrying Out Investigations:

Conduct an investigation to produce data to serve as the basis for evidence that meets the goals of an investigation. (MS-LS1-1)

Constructing Explanations and Designing Solutions:

Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5),(MS-LS1-6)

Engaging in Argument from Evidence:

Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)

Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence. (HS-LS3-2)

MS.Engineering Design

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

HS.Engineering Design

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem-based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Common Core State Standards Connections:

ELA /Literacy –

RST .6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS3-1),(MS-LS3-2)

RST .6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. (MS-LS3-1),(MS-LS3-2)

RST .6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2)

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS3-1),(MS-LS3-2)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS3-1),(HS-LS3-2)

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-LS3-1)

WHST.9-12.1 Write arguments focused on discipline-specific content. (HS-LS3-2)

Mathematics –

MP.4 Model with mathematics. (MS-LS3-2) (HS-LS4-2)

6.SP.B.5 Summarize numerical data sets in relation to their context. (MS-LS3-2)

MP.2 Reason abstractly and quantitatively. (HS-LS3-2),(HS-LS3-3)

C3 Framework for Social Studies Standards:

Developing Claims and Using Evidence:

D3.3.6-8. Identify evidence that draws information from multiple sources to support claims, noting evidentiary limitations.

D3.4.6-8. Develop claims and counterclaims while pointing out the strengths and limitations of both.

D3.3.9-12. Identify evidence that draws information directly and substantially from multiple sources to detect inconsistencies in evidence in order to revise or strengthen claims.

D3.4.9-12. Refine claims and counterclaims attending to precision, significance and knowledge conveyed through the claim while pointing out the strengths and limitations of both.

Communicating Conclusions:

D4.1.6-8. Construct arguments using claims and evidence from multiple sources, while acknowledging the strengths and limitations of the arguments.

D4.2.6-8. Construct explanations using reasoning, correct sequence, examples, and details with relevant information and data, while acknowledging the strengths and weaknesses of the explanations.

D4.3.6-8. Present adaptations of arguments and explanations on topics of interest to others to reach audiences and venues outside the classroom using print and oral technologies (e.g., posters, essays, letters, debates, speeches, reports, and maps) and digital technologies (e.g., Internet, social media, and digital documentary).

D4.1.9-12. Construct arguments using precise and knowledgeable claims, with evidence from multiple sources, while acknowledging counterclaims and evidentiary weaknesses.

D4.2.9-12. Construct explanations using sound reasoning, correct sequence (linear or nonlinear), examples, and details with significant and pertinent information and data, while acknowledging the strengths and weaknesses of the explanation given its purpose (e.g., cause and effect, chronological, procedural, technical).

D4.3.9-12. Present adaptations of arguments and explanations that feature evocative ideas and perspectives on issues and topics to reach a range of audiences and venues outside the classroom using print and oral technologies (e.g., posters, essays, letters, debates, speeches, reports, and maps) and digital technologies (e.g., Internet, social media, and digital documentary).

Elementary (Second Professional Development):

Next Generation Science Standards:

Disciplinary Core Ideas:

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

LS1.C: Organization for Matter and Energy Flow in Organisms

LS2.A: Interdependent Relationships in Ecosystems

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

Crosscutting Concepts:

Systems and System Models: A system can be described in terms of its components and their interactions. (5-LS2- 1)

Energy and Matter: Matter is transported into, out of, and within systems. (5-LS1-1)

Science and Engineering Practices:

Support an argument with evidence, data, or a model. (5-LS1-1)

Develop a model to describe phenomena. (5-LS2-1)

Science explanations describe the mechanisms for natural events. (5-LS2-1)

Elementary 3-5 Engineering Design:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Common Core State Standards Connections:

ELA/Literacy –

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-LS2- 1)

RI.5.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s). (5-ESS1-1)

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-ESS1-1)

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5- LS2-1)

Mathematics –

MP.2 Reason abstractly and quantitatively. (5-LS2-1)

MP.4 Model with mathematics. (5-LS2-1)

MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multistep, real-world problems. (5-LS1-1)

C3 Framework for Social Studies Standards:

Developing Claims and Using Evidence

D3.3.3-5. Identify evidence that draws information from multiple sources in response to compelling questions.

D3.4.3-5. Use evidence to develop claims in response to compelling questions.

Communicating Conclusions

D4.1.3-5. Construct arguments using claims and evidence from multiple sources.

D4.2.3-5. Construct explanations using reasoning, correct sequence, examples, and details with relevant information and data.

D4.3.3-5. Present a summary of arguments and explanations to others outside the classroom using print and oral technologies (e.g., posters, essays, letters, debates, speeches, and reports) and digital technologies (e.g., Internet, social media, and digital documentary).

https://www.nextgenscience.org/sites/default/files/AllDCI.pdf
https://www.socialstudies.org/sites/default/files/2017/Jun/c3-framework-for-social-studies-rev0617.pdf

IV. Summary of Project

My colleagues are interested in adopting the NGSS. So I wanted to expose them to three-dimensional teaching and the 5E model as a way of showing an application of *explore-before-explain* teaching method. Moving to an *explore-before-explain* model will allow for student ideas to become explicit. In an *explore-before-explain* classroom, student experiences are not just hands-on but minds-on because they are integrated with the flow of instruction. Students are given the opportunity to show what they already know and are then tasked with the challenge of making sense of scientific phenomenon. Three-dimensional learning promotes an intentional shift from presenting lessons of isolated facts to one where students are actively using logical reasoning and science practice to show knowledge transfer. Students learn to act and think like scientists. Students base an accurate understanding of science on the knowledge they construct from practices they have used. Deep understanding and supported knowledge are contextualized through firsthand experiences. Students that explore science first learn to link science processes with specific content giving them a more accurate view of science and scientific thinking that they can then translate to their own lives.

V. Pre-Survey Questions

- How familiar are you with Next Generation Science Standards? (no clue, limited knowledge, some knowledge, good knowledge, use them daily)
- How familiar are you with Explore before Explain Methodology? (no clue, limited knowledge, some knowledge, good knowledge, use this method daily)
- How familiar are you with the 5E instructional sequence? (no clue, limited knowledge, some knowledge, good knowledge, use this method daily)
- How often do you use online simulations with your students to model real-world problems? (Never, Bi-monthly, Monthly, Weekly)
- How familiar are you with scaffolding a simulation to bring about engaged inquiry to pose and answer questions not addressed by traditional classroom methodology? (No clue, Some knowledge, Comfortable, Proficient)
- How much do you incorporate STEM into your current teaching? (Never, Bi-monthly, Monthly, Weekly, Daily)
- Rate your level of comfort in implementing STEM into everyday instruction. (Not comfortable, Low comfort, Comfortable, I have no problem)
- How often do your students make subject area content connections to the world around them on their own? (Never, Sometimes, Often, Weekly, Daily)
- How often do you challenge your students to apply your content to their daily lives?
- Have you ever received any formal STEM training or PD on pedagogical instruction in STEM? (none, 1-6 hours, 7-15 hours,15+ hours)

- How familiar are you with NASA resources for your subject/content area? (No Clue, limited knowledge, some knowledge, good knowledge, use them bi-monthly, use them monthly, use them weekly)

VI. Brief Description of the Actual Professional Development Training

The professional development began with a brief video that contrasted past learning to learning in the 21st century. The video gave a great overview of 21st century skills and the reasons why creativity, critical thinking, communication and collaborations are so necessary for our students today. By drawing inspiration from the Project Based Learning coursework and Tony Wagner, I learned the importance of developing the creative and enterprising capacities of all our students because “only the jobs of innovators and entrepreneurs will be immune to outsourcing or automation in the new global knowledge economy” (Wagner, 2012).

I spoke briefly about the differences a traditional teaching model and that of exploration. Immediate experience is not at the heart of the traditional method. Instead, it emphasizes the teacher’s explanation as the central role in learning, and data just supports ideas that have already been presented. Students tend to “fit” the data from these experiences into what has been said and are often left with a false understanding of the nature of science (Brown, 2018). Explore-before-explain places the experience first and the explanation second. The hands-on nature of an activity is then transformed to a minds-on experience because the experience is **integrated with the flow of instruction**. I wanted to emphasize the importance of sequence so that students can actively connect the WHY we are doing a lesson with the HOW we facilitate the lesson (Huling, & Speake Dwyer, 2018).

I then introduced what three dimensional learning is and how to connect the three dimensions with the 5E lesson plan model. I began by introducing a phenomenon in a picture and transitioned to the mini- 5E lesson plan.

Prior to training, participants filled out an online Google form survey. This pre-assessment allowed for the collection of data on current teaching practices with simulations, familiarity with Next Generation Science Standards and the 5E teaching model.

Participants were led through a simple lesson plan allowing the teachers to interact as students in the 5E teaching model. By using a lesson Genetics, most teachers were not familiar enough to give the easy answers. Therefore, they were able to interact as students. I paused to allow them to explore a simulation and settled into a role as facilitator as if I was facilitating a lesson in my classroom. Teachers were naturally curious and interacted with the online simulations and associated NASA resources. I then progressed through a 5E lesson model giving usual think time and then producing artifacts that students had given in the unit during a prior class unit.

After completion of the trainings, participants were asked to complete an online Google form post-survey.

NOTE: For the elementary PD, I used ecosystems as the lesson. A simulation of a forest ecosystem was used to show how to scaffold an ecosystem and explore the phenomenon of animal/environment interactions. I then led the participants through a 5E model plan in a similar manner. See Appendix A for Elementary presentation.

VII. Brief Outline of the Activities in the Pick-up Unit

I. Pre-survey

II. Brief Explanation of 3D's and how they connect with 5E's why explore-before-explain is important

III. Mini Lesson Genetics Middle/High School PD: Modeled in 5E methodology with discussion of how this was modified from a traditional methodology.

A. Engage: Simulation discovery activity NASA or Gizmos (teacher preference). This incorporated what I learned from the Physical Science course on how to moderate simulations to bring about critical thinking and extract misconceptions.

B. Explore: Participants were walked through a lab using Wisconsin Fast plants. A phenomenon question was introduced to activate student's prior knowledge of punnett squares to formulate a Claims, Evidence, Reasoning chart that they used to plan an investigation to collect data first hand. Teachers were also shown how to modify questions to make them into guiding questions. This was modeled in a Stop and Think section that allowed scaffolding of the lab to lead to student development of the CER chart.

C. Explain: Students were shown the results of the experiment with the plants (I had set these up prior to the professional development). Teachers were then able to revise a student CER and propose further experiments using more than one trait.

D. Evaluate: Several of the participating teachers were math teachers. This section gave a place to incorporate more interdisciplinary math integration with Chi Square analysis. Other connections were made to Environmental and Physical science through discussion of other traits that are affected by different wavelengths and light intensities. This allows for transfer to occur as students can now design experiment to test the effects of environmental factors on gene expression.

E. Extend/Elaborate: I was able to show the extension that my students did with Wisconsin Fast plants and expression of two traits. Engineering Challenge possibilities of student interest.

IV. Post-Survey

VIII. What NASA data did you include?

- Teachers were encouraged to use the NASA Resources Search Tool to find a NASA resource suitable to their needs.
- Online PhET simulations were introduced in the Physics NASA Endeavor class. Scaffolding for simulations were derived from this video. Since we are a 1:1 iPad school I used preselected Gizmos simulations for easy access and to help save time during the PD. The following resources were linked in the handout for the PD:

  Elementary:
  https://phet.colorado.edu/en/simulations/category/by-level/elementary-school

  Middle School:
  https://phet.colorado.edu/en/simulations/category/by-level/middle-school

  Middle School NGSS Alignment and PhET

  Middle School Scope for PhET

  High school:
  https://phet.colorado.edu/en/simulations/category/by-level/high-school

High School NGSS Alignment and PhET
Additional Math Resources from NASA:

- **https://spacemath.gsfc.nasa.gov/grade.html**
- **https://spacemath.gsfc.nasa.gov/Standards.html**
- **https://www.nasa.gov/audience/foreducators/exploringmath/algebra1/index.html**
- **https://spacemath.gsfc.nasa.gov/books.html**

Additional Elementary/Middle School Resources:

- Animal Tracking http://www.signalsofspring.net/
- Winged Ambassadors http://www.downloadwingedambassadors.org/

IX. Follow-up Activities and Post-Survey Questions

- After the PD, how has being introduced the Next Generation Science standards going to influence your teaching? Specifically, do you now see connections across disciplines even outside of science? (Cause and effect, marketing, critical thinking, constructing timelines, historical implications, math applications)
- After the PD, how has being introduced the Explore before Explain model going to influence your teaching? Do you see yourself shifting to this type of methodology?
- After the PD, What advantages do you see Explore before Explain model for student engagement/learning?
- After the PD, how has being introduced the 5E teaching method going to influence your teaching? Do you see yourself shifting to this type of methodology?
- After the PD, What advantages do you see in using the 5E teaching method for student engagement/learning?
- Rate your level of comfort in incorporating STEM into your daily current teaching?
- Did the PD spark an interest in cross-curricular approaches to your subject area? (PLEASE Explain in Other Section)

- Would you be interested in sitting down to collaborate on some lessons to integrate this type of cross-curricular approach? If Yes, what areas do you see your subject tying into STEM?
- Would you be interested in planning a long-term project across disciplines to implement cross-curricular connections?
- Would you like further professional development to learn how to incorporate STEM into your subject matter?
- What is your biggest obstacle in implementing STEM content?
- After the PD, are you familiar with NASA resources and how they could be incorporated for cross-curricular connections in your classroom?
- How often do you think you will use online simulations with your students to model real-world problems?
- Do feel that you can now scaffold a simulation to bring about engaged-inquiry to pose and answer questions not addressed by traditional classroom methodology?
- Which part of the PD was most effective for you?
- Anything you would like to add?

X. Outcomes: Final Data Collection and Analysis

A. Survey Results/Comment on the content included in the project

Participants in the PD were encouraged by the information presented. 95% of participants said that they had no clue to limited knowledge of the Next Generation Science Standards prior to the PD. After the PD 100% felt that they could see connections across disciplines outside of science. One teacher stated that the “math involved in the NGSS is impressive. The connections that the students make using critical thinking skills brings the lessons to life”. Another stated that she wanted to use NGSS to “incorporate more math applications within the ELA lessons as well as science...this way we can work through more standards in one activity”.

100% of participants prior to the PD had no clue to limited knowledge of the Explore before Explain 5E instructional model. After the PD most would at least try this method. One stated “I see that by allowing them more hands-on experiences before a lesson, they will make connections on their own using their own skills". Another said "it really hit me that it's easier to explain something after the kids have explored it".

95% of participants said that prior to the PD they never incorporated stem or they did it monthly. After the PD, all participants had increased their willingness to incorporate STEM more often in their teaching.

B. Survey Results/ Comment on the pedagogy in the project

After the PD, all of the teachers saw the value of an Explore before Explain 5E model. Teachers understood that misconceptions could be drawn out as one teacher put it "you get the opportunity to see what they already know before connecting to the new skill...they also get to see more connection and the 'why' of concepts". Another teacher said that the "students will enjoy the lesson more because they are engaged in it from the beginning...they will remember more of the information because they were so involved in the learning...remembering the experience and the discoveries they made". They also picked up on the fact that students engagement would be the driving force of the lesson placing the "responsibility of learning on the student, and the teacher's role is to set up the opportunity for learning".

C. Was your professional development successful? Why or Why Not?

The professional development was very successful as many of the participants felt more comfortable with three dimensional learning. Almost all of the participants stated that they would use simulations more often to engage students in exploration learning. One big realization was that teachers felt that they could capitalize on their students failures in a way that would bring about a positive learning outcome. Students are able to step back and look at their failures to evaluate prior knowledge and transfer tasks to lead to better understanding of task at hand. So prior knowledge is activated and used in a new set of circumstances.

The move from teacher as transmitter of information to facilitator of information was obvious to the participants. This led the teachers to realize the power of discovery in creating student problem solvers that use critical thinking and not just student direction followers that are only motivated by a product. In other words, teachers use exploration to create active learners instead of passive listeners. Many teachers realized how this promotes active learning by students and moves failure to a positive element of the learning cycle. One elementary teacher stated “It really hit me that it’s easier to explain something after the kids have explored it. Many kids have no prior knowledge on many of the topics we teach.”

Exposure to the Next Generation Science Standards allowed many teacher to see more connections. It was more obvious how to incorporate math, science and other subjects into a single standard. One participant stated “the standards are easier to connect to a variety of topics and thinking skills.” When thinking about math another commented “The math involved in Next Generation is impressive. The connections that the students make using critical thinking skills brings the lessons to life”.

D. How did this project relate to the readings? Cite two examples.

1. Desimone, L.M. (2011). A Primer on Effective Professional Development. Phi Delta Kappan, 92(6), 68.

Desimone presents five core features necessary to execute an effective professional development.

- Content focus: Professional development should focus on subject matter content and how students learn. I framed my PD so that the teachers became the students and explored through doing.
- Active learning: Teachers in my PD interact with a simulation. By having them do it, I could show them how to frame a simulation using their real time questions and interactions.
- Coherence: What teachers lean in any PD should be consistent with other professional development, with their knowledge and beliefs, and with school, district, and state reforms and policies. The CER examples showed a connection to our Socratic process and incorporated critical thinking skills that we have focused on this year.
- Duration: The PD was too short. This is one area I would like to put together a PLC for science and math next year so we can further develop this type of PD into something with more contact time so it is more sustaining.
- Collective participation: Groups of teachers from the same grade, subject or school should participate in professional development activities together

to build an interactive learning community. One teacher commented that she wanted to use the simulations that were science based to engage them in meaningful math lessons that they could then connect in real-world ways.

The three outcomes suggested as a framework for testing effective professional develop in the article is what I based my post survey questions on. They were: Do teachers learn? Do they change their practices? Does student achievement increase as a result?

2. Lustick, D.S. (2011). Experienced Secondary Science Teachers' Perceptions of Effective Professional Development while Pursuing National Board Certification. Teacher Development, 15(2), 219-239.

Lustick attributes the success of the National Board certification process to the reflective nature of the program. When selecting the activities for my PD, I looked for a lab that had brought about some great learning in my students. When we think about our methodology and then select PD based on our own needs and student outcomes then we are improving our craft. I think the success of the PD that I did was due to the fact that it was a teacher showing other teachers a new technique. Furthermore, Lustick points to the reform approach to PD as it “sees the teacher as an active learner and the process of learning embedded in practice” as well as” the role of reflection and professional discourse as vital to productive teacher learning” (Lustick, 2011, p. 224). In conclusion, Lustick identifies strong emphasis on content, individuals owning learning and goal oriented student learning as key to a model PD. These three are important because they place “individual at the center of the active learning process” (Lustick, 2011, p. 235).

E. Will the teachers do these activities again?

I definitely think that the teachers would use these simulations again. It was interesting to hear teachers talk about how they could connect the simulations to other units they were developing. One math teacher was encouraged to use the simulations in her online teaching as a way to better engage distance learners.

The modeling of the 5E methodology and engaging teachers as learners helped them to draw more connections to their individual areas of expertise. The sole literature teacher in the group was surprised by the applications of a science lesson to how literature could be taught. He stated that "I think it confirms my method in using Socratic as a high-engagement, student driven model of teaching", adding "This model lets student engagement drive the lesson; it places the responsibility for learning on the student, and the teacher's role is to set up the opportunity for learning."

F. Reflection

This experience helped me put into practice what I have learned through the NASA Endeavor program. It was a challenge for me as I was invited to additionally do an elementary PD. The biggest challenge was I had to think of ways to incorporate STEM outside of science. In the Middle/High school PD this was important because we are a small school and I needed more than just my department to participate. As a backup plan, I looked into doing an elementary PD. That experience forced me to think of ways to make STEM more accessible to younger learners. So what could be an inspiration for an engineering design project for older students ie The Three Little Pigs becomes the end product for elementary learners.

My abilities to scaffold for a larger audience of learners was stretched because I had to change vocabulary and adjust the pace of the unit for younger learning groups. The Elementary PD helped me to visualize the multi-disciplinary connections and I learned more about how to unpack the Next Generation Science Standards to incorporate all core subjects and not just science.

Utilizing the explore-before-explain 5E model and actively engaging the teachers into their own PD (treating them as students) really helped them to realize the possibilities that this methodology would bring to their classroom, especially, in the areas of critical thinking and the concept of failure as a learning tool to success. By modeling, the simulations and giving scaffolding instructions to the participants they were able to see the effect that technology would have in their classroom. This gives a new dimension to learning.

The introduction of three dimensional learning especially engineering practices also brought to light the career teaching that can take place at an early age. The technology with the simulations also capitalizes on the students sense of play and activates their curiosity to work in ways that traditional methodology of skill and drill does not allow.

Appendix List

A. **Pick Up Lesson Elementary**
B. **Links to Resources and Google Slides used for PD Workshop**
C. **Student artifacts and data**
D. **Teacher Contacts**

Works Cited

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Appendix A: Pick-up Lesson Elementary

III. Mini Lesson Ecosystems Elementary School PD: Modeled in 5E methodology with discussion of how this was modified from a traditional methodology.

A. Engage: Video from PBS learning https://unctv.pbslearningmedia.org/resource/f1fbcd8b-d2b4-4b0b-acc8-5647d5b81241/blue-whale-barrel-roll/. This video sparked interest in how animals feed and interact. Prior knowledge was activated through a brief story of an imaginary animal whose habitat went through a drastic change.

B. Explore: Simulation discovery activity NASA or Gizmos (teacher preference). This incorporated what I learned from the Physical Science course on how to moderate simulations to bring about critical thinking and extract misconceptions. Participants used an ecosystem simulation from Gizmos to see how adding and removing organisms affect populations. From here students can formulate a Claims, Evidence, Reasoning chart that they used to plan an investigation to collect data first hand from the simulation. Teachers were also shown how to modify questions to make them into guiding questions. This was modeled in a Stop and Think section that allowed scaffolding of the lab to lead to student development of the CER chart.

C. Explain: Participants were then invited to do a hands on activity where they were each assigned different animals and their prey organisms. First they were told to organize into food chains. Next, participants were organized into a circle and threw a ball of yarn back and forth creating a food web.

D. Evaluate: Participants were redirected to the simulations with guided worksheet to allow students to evaluate and graph results. Additionally, new sets of organisms can be given and students can generate their own food chains and food webs.

E. Extend/Elaborate: Math connections were made when the food chains were drawn out and the energy movement was modeled.

Because 10% is passed on to the level above students can practice place values.

Appendix B: Links to Resources and Google Slides used for PD Workshop

Middle School/High School Slides:
https://docs.google.com/presentation/d/16RzxjMn0elKbe5kcbvbT-LYP3qlsuwCN3ay7XG7PKD0/edit?usp=sharing

Elementary School Slides:
https://docs.google.com/presentation/d/12TcMVXy-NJ9Lb4mcMsjLORqVlf29hDjuoaGvXYfNAAg/edit?usp=sharing

Notes with Resource Links:
https://docs.google.com/document/d/1j5linIRBkTF3GYUQLtFU_VQY2wlZ_w-r8MX_BaheAzI/edit?usp=sharing

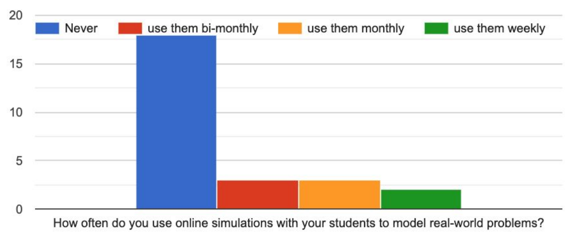
Appendix C: Student artifacts and data

[Pre-Assessment Survey Link]

[Post-Assessment Survey Link]

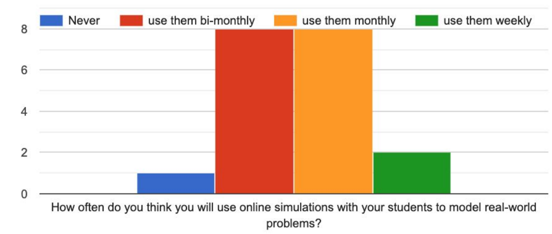
Pre-Survey

How often do you use online simulations with your students to model real-world problems?



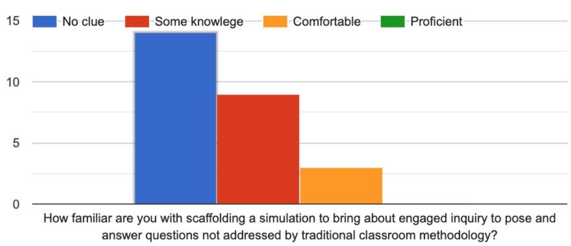
Post-Survey

How often do you think you will use online simulations with your students to model real-world problems?



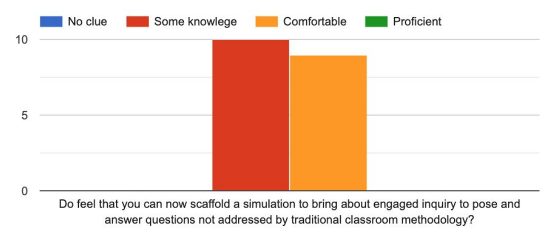
Pre-Survey

How familiar are you with scaffolding a simulation to bring about engaged inquiry to pose and answer questions not addressed by traditional classroom methodology?



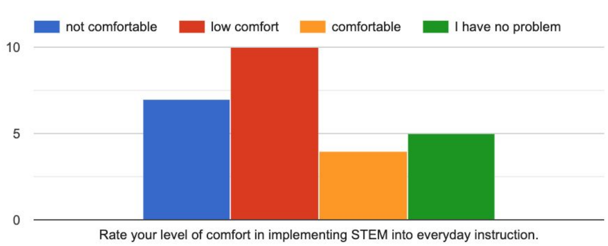
Post-Survey

Do feel that you can now scaffold a simulation to bring about engaged inquiry to pose and answer questions not addressed by traditional classroom methodology?



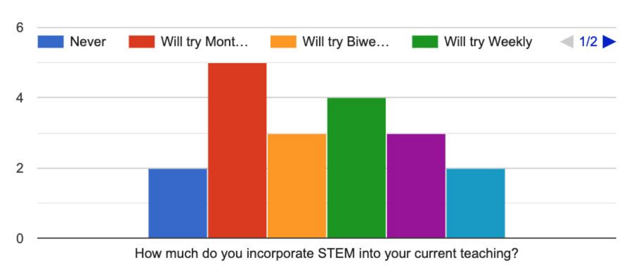
Pre-Survey

Rate your level of comfort in implementing STEM into everyday instruction.



Post-Survey

Rate your level of comfort in incorporate STEM into your daily current teaching?



Appendix D: Teacher Contacts

https://docs.google.com/spreadsheets/d/1c364dbDPvyBRLcJCR9Q8n_r86SB5bG2fUxSaHvGg3pk/edit#gid=1906031037