Making a Transdisciplinary Curriculum Action Based and Hands-On

NASA Endeavor STEM Teaching Certificate Project

SCED 545: STEM Leadership Seminar

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Background

Rose Stein International Elementary (RSI), is a newly accredited IB World school. Following the initial authorization, all schools must undergo regular re-evaluations to ensure ongoing quality and adherence to IB ethos. A large part of that ethos is Transdisciplinary teaching and learning.

In a transdisciplinary curriculum,traditional subjects are absorbed through projects or learning centers that teachers plan with input from children. The learning experiences should give teachers the opportunity to extend ideas, respond to questions, engage students in conversation, and challenge their thinking (Ozer, 2010).

Although there may be excitement for implementing transdisciplinary curriculums for the IBO, many teams and individual teachers at RSI feel a deficit in their own efficacy (Lakshmanan, 2011). Teacher self-efficacy coincides with their professional beliefs, which "may play a crucial role in the actual implementation of reform recommendations as their beliefs lead to specific actions in the classroom" (Czerniak, Lumpe, & Haney, 1999).

This Professional Development (PD) opportunity focused on integrating Earth and space sciences with other disciplines such as graphic arts, reading, and mathematics. By actively modeling a lesson in this way, transferable activities could be shared, the pedagogical content knowledge of the staff could be increased, and resources for independent attempts could be shared authentically.

Standards

This teacher training centered around two NGSS standards. One asked learners to identify evidence from patterns in rock formations, and the other expected observations and/or measurements to provide evidence of the effects of Cause and Effect (NGSS Lead States, 2013). The Literacy standards were most evident in the Explore phase of the PD, and focused on investigating a topic, and gathering relevant information. The clearest application of mathematics in this lesson was the use of measurement tools. Finally, visual arts were integrated as participants were asked to identify and analyze characteristics of form and structure. For complete standards please reference Appendix D.

Participants

Participants were gathered from the school staff of Rose Stein International Elementary. E-mails were sent with an optional interest survey attached. In order to build a sense of readiness and commitment from the faculty, the survey allowed teachers to pick which disciplinary concept they would like to review (Jenkins & Yoshimura, 2010, p.38). Four staff members attended the PD: Jessica Strauss (3rd grade), Whitney Rutledge (4th grade), Brooke Rawls (Intermediate Specialist), and Franco Rodriguez (IB coordinator and instructional coach). Each participant was expected to join the learning and stay for an hour over two sessions. Participants were not compensated for their time.

Summary of Professional Development

The goal of this PD was to increase teacher confidence and efficacy with integrating STEM subjects and resources. The training was designed to make use of the "design elements of effective professional development" as reported by Darling-Hammond et al. (2017). Specifically, the modeling of a 5E lesson allowed for active learning– engaging the participants, and building their familiarity with a new process for students.

The training started with a brief summary of why participants had gathered, and what the outcomes of the PD would be. Initially, a formative assessment of 5E lesson design, and a survey around confidence levels was produced (see appendix A).

The 5E lesson. Participants began to *Engage* by looking at high quality photographs of the Martian surface. Inquiries were made outloud and recorded for reference. The *Explore* phase consisted of a small erosion lab, and several differentiated texts. In the lab, participants were required to predict what motion/cause would create a shape/effect on the granular surface of hot cocoa and flour. After testing their theories, teachers would draw and label what shapes they saw as a result of their action. The Explore phase continued with reformatted texts from JPL's resource "Art and the Cosmic Connection" (see appendix B). This allowed participants to clarify their comprehension of the content, and view a model of effective differentiation practice (Darling-Hammond et al., 2017). After this clarification, participants were asked to write a short summary of their current understanding for the *Explain* phase. The educators present discussed the different ways that the Explain phase could be made more or less rigorous for different grade levels and diverse learners. The *Elaborate* phase challenged the participants' grasp of the content by asking them to further analyze and compare similar formations like craters. In summation, the participant's comprehension was *Evaluated* through a short exit task. Teachers were given a color enhanced image of the Martian surface to identify and label as many features as they could find. This phase ended with a discussion and challenges to existing thinking.

The analysis. The same participants came together two days later to metacognitively analyze the pedagogy and the content of the lesson. Participants were asked three questions by the facilitator:

1)How did I incorporate ELA, Math, and Social Studies?

2)How could I have incorporated more of those disciplines?

3)How are IB Approaches to learning being implemented?

After discussing these questions in depth, a list of resources was provided for the participants to explore. The group discussed some of the resources in their connection with transdisciplinary planning and hands-on learning.

The resource distribution. A document containing links, with their corresponding screenshots, of STEM resources was provided to teachers in digital and print form (see appendix C). Participants opened resources together to discuss how they would use them in future lessons. Some participants were able to add provided resources to their current IB planner.

NASA/Endeavor Integration

Monica Aiello was a guest speaker for the Spring 2022 Endeavor class *The Arts in STEM: Advancing Meaningful Integration*. She shared some of the resources available for educators from NASA's Jet Propulsion Laboratory. "Art and the Cosmic Connection", the classroom activity that inspired this PD, was produced by Aiello. The cause and effect lab was inspired by a NASA activity called "How to Make a Crater" (2013).

Additionally, the resource acquisition session exposed participants to almost every resource Endeavor has provided for program members. This includes resources from NOAA, PBS Kids Design Squad, Earth Observatory, and more.

Methodology

A mixed methods approach was used to collect data on the impact of the PD. There was no concealment around the nature of the data, or how it would be used.

The quantitative portion contained a five part questionnaire with corresponding 7-point likert scales. One represented "not at all confident," and seven represented "extremely confident" (See Appendix A). The questionnaire revealed confidence levels in relation to transdisciplinary planning, hands-on activities, engineering, planetary science, and the incorporation of math and social studies with science.

The qualitative portion consisted of formative inquiries during the lesson, and concrete follow-up questions posed a week after the PD.

Qualitative Results

When formatively assessed on the lesson design of 5E, no participants expressed familiarity. During the engage phase of the lesson, the majority of participants felt the photographs may have to do with space. This showed previous knowledge of the content. However, no participants correctly predicted the reason [seismic activity] for straight lines on a surface. This lack of understanding came to the forefront once more when participants predicted what would happen when we shook the basin. All four participants predicted that the surface would just slide around and fill itself in, however, upon experimenting we found the the surface cracked and left straight lines.

When asked to analyze the transdisciplinary nature of the lesson, teachers felt much more confident. Teachers called out with: "Geometry," "schema," "leveled reading," "collecting data," "measurement," "debate," "art." They were able to pick out standards, content, and IB learner profile attributes.

When asked to brainstorm new ways to make the lesson transdisciplinary, teachers seemed excited and engaged. Some ideas provided by teachers included: " compare and contrast writing," " 3D art," "Greek/ Latin root word inquiry," "maps throughout history," "photography," "angle of impact," and "fables." Teachers seemed to be thinking in very abstract ways, which is exactly what transdisciplinary planning requires.

When given the formal follow-up questions, there was a trend of teachers making connections to other subjects. Three of the four participants mentioned the 5E model, and three of the four participants made note of the resource list.

How has your confidence changed with integrating science?

I've become more confident by feeling more at ease when implementing science into all subjects! Especially coming from a school that wasn't IB before.

I found the PD to be very helpful. I felt inspired by the idea of how transdisciplinary teaching can bring connectedness and passion to our students. I loved the science resources that were offered. I particularly enjoyed discovering how art and science can work together beautifully.

My confidence definitely increased after your guided direction and modeling of the science/astronomy experiment and the variety of resources that you provided. You gave multiple strategies for integration of other disciplines which was helpful for confidence building. In addition, you clearly demonstrated how to use higher level thinking questions and the 5E model to allow for greater engagement during student learning.

I feel more confident with showing other teachers how they can integrate science more easily. As a coach I love having resources that I can bring to teachers in need.

What was the most helpful part of the PD for you?

The most helpful part of the PD was the introduction of the 5E model. I think this would be a great way to incorporate more IB action based projects!

The most helpful part of the PD was the variety of resources provided, the sample lesson model with the experiment, the opportunity to self-reflect and ask questions, and your thorough planning and alignment with the 5E model in your own presentation. Thanks for such a great professional development learning opportunity! It was so beneficial and gave me more great ideas for my IB units.

I found the lab to be the most helpful. I felt really engaged, which made me reflect on my students. I want them to feel engaged too. I'm so worried about teaching all the other core subjects though.

Quantitative Results

Since there were only 4 participants, we can analyze growth in each realm (See Table 2). Analysis of the surveys provides insight into confidence growth among teachers. Every teacher who participated grew more confident in every aspect of the questionnaire.

The confidence level of teachers when it came to *integrating other subjects with science* saw one of the largest measures of growth. Before the PD, the participants had an average score of 2.5 on the likert scale of confidence. After the PD the average was 6.25.

Similarly, their confidence around *integrating planetary science* saw growth from an average of 2.5 before the PD to an average of 6.75 after the PD. Confidence levels around using *hands on activities* grew from their prePD average of 2.5 to a postPD average of 5.75. Participants' confidence around *integrating mathematics* grew from an average of 2.5 before the PD to an average of 6 after the PD. The lowest scores were seen in *integrating engineering*. Participants went from an average of 1.75 to an average of 4.5.

Table 2.

	pre PD confidence	post PD confidence	growth
How confident do you feel making lessons transdisciplinary with science?	2	7	+5
	3	6	+3
	2	6	+4
	3	6	+3
How confident do you feel incorporating hands-on activities in the classroom?	3	6	+3
	3	6	+3
	1	5	+4
	4	6	+2
How confident do you feel incorporating engineering into your classroom?	2	5	+5
	2	5	+4
	1	4	+5
	2	4	+3
How confident do you feel incorporating planetary science into your classroom?	2	7	+5
	2	6	+4
	2	7	+5
	4	7	+3
How confident do you feel incorporating math into subjects like science and social studies?	2	6	+4
	2	6	+4
	2	6	+4
	4	6	+2

Personal and Course Related Reflections

Overall, I felt as though the professional development was a success. I believe success in this case is measured by growth in confidence and enthusiasm for STEM. The quantitative data showed a clear pattern of growth in confidence. I am very aware of the limitations that come with surveys. Although my participants were not compensated, they could have marked higher growth scores to be polite, or encouraging. With this in mind I was excited to look at the written responses. I think the qualitative data partially counterbalances this limitation. Their responses seemed genuinely informed and enthusiastic.

This project was heavily influenced by Darling-Hammond's elements of effective PD design (2017). I made sure the content worked with my audience, because I wanted an "intentional focus on discipline-specific curriculum development"(Darling-Hammond et al., 2017). I made sure to use the Active learning strategy of a hands-on 5E lesson because when facilitators deftly integrate a protocol, routine, or activity that educators will replicate, they manage to achieve two goals. The first goal met is the educators' engagement in the learning, as the activity will be chosen with the intention for effective outcomes (Darling-Hammond et. al., 2017). And finally, I made sure that the PD went on for more than one session to achieve some sustained duration. I wanted the PD to be over four days, but that didn't work well for the participants' schedules.

As I finished the PD section of the project I was reminded of the sentiment by Berry et al. in which they claim "opportunities for collaboration and leadership (within and beyond the classroom) can increase teacher efficacy and effectiveness, and improve the retention of the classroom experts students deserve" (2010). I felt like the leadership opportunity increased my efficacy, and thus effectiveness as a teacher. Additionally, I hoped that my participants would be and example of the "positive correlations between subject-specific professional development and student achievement growth" (Berry et al., 2010).

My deepest hope upon reflection is that these teachers will actually implement what I shared in the training session. Two classroom teachers have already spoken about their excitement to use the online resources that were provided in the second session. My larger hope is that they will incorporate the 5E lesson design into their planning. As a minimum impact, I would like to see teachers starting to utilize engaging phenomena.

When analyzing the effectiveness of PD on content I can only use my formative data. It seemed as though teachers had a deeper understanding of planetary surface forms and their meaning by the end of the session. Their written *explain* phase showed that they understood the main idea of each shape. In the future I would like to create a new PD that focuses more on content as my results don't seem definitive.

With an understanding of this project's limitations, I still confidently believe that PD can be incredibly effective when teaching pedagogy. When teachers learn using the method they will teach with, they leave with experience, perspective, and new tools to try in their own classroom.

References

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Appendix A

Likert Scale questions for pre and post assessments

How confident do you feel making lessons transdisciplinary with science?

Not at all Confident 1	2	3	4	5	6	Extremely Confident 7
○	○	○	○	○	○	○

How confident do you feel incorporating hands-on activities in the classroom?

Not at all Confident 1	2	3	4	5	6	Extremely Confident 7
○	○	○	○	○	○	○

How confident do you feel incorporating engineering into your classroom?

Not at all Confident 1	2	3	4	5	6	Extremely Confident 7
○	○	○	○	○	○	○

How confident do you feel incorporating planetary science into your classroom?

Not at all Confident 1	2	3	4	5	6	Extremely Confident 7
○	○	○	○	○	○	○

How confident do you feel incorporating math into subjects like science and social studies?

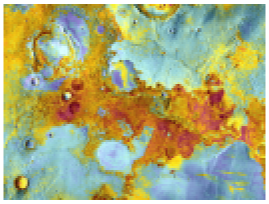
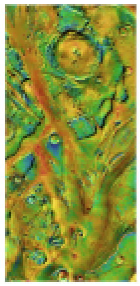
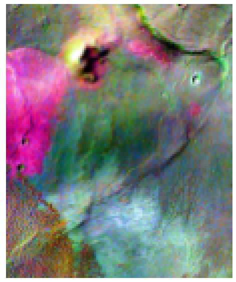
Not at all Confident 1	2	3	4	5	6	Extremely Confident 7
○	○	○	○	○	○	○

Appendix B

Materials for Participants

"5 E" lesson

1. Engaging phenomena - High Quality photographs of the surface of Mars

2. Explore- Participants will take part in a mini-lab before exploring leveled texts
    a. Mini-Lab materials: flour, cocoa, cake sprinkles, water
    b. Recording Observations:

Consider how these could be made more rigorous for different grade levels-

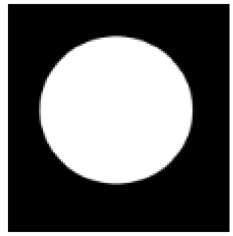
Could you ask for more detailed adjectives? etc.

Action (example: shaking)	Prediction "I predict ________ will make a _______ shape."	Observations Draw the shape

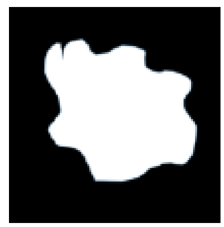
Shapes From Above

Information from the Jet Propulsion Laboratory at the California Institute of Technology
Adapted by Ms. Ellison

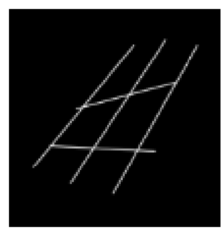
- **Circle** – When circles are viewed on a planetary image, it is most likely, a crater. The size, shape, rays, and number of craters give important clues about the history of a *planetary body*. Sometimes circular features are volcanic, such as the pancake domes found on Venus, for example.



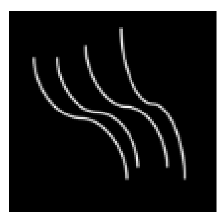
- **Blobs** – Organic shapes, or blobs, can often be interpreted in two ways. Blobs frequently mean that one is viewing volcanic processes and lava flows. Blobby shapes can also indicate existing bodies of surface liquid (rivers and seas) or ancient bodies of liquid that left remnants of dried beds.



- **Straight Lines** –Seeing straight lines on a planetary body often means there is *tectonic* activity, like earthquakes. This could include faults, ridges, cracks and mountains. On Earth, tectonic activity is thought of as just occurring on land; it can also be present in icy worlds.



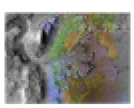
- **Squiggly Lines** – The presence of squiggly lines on the surface often tells us forces of *erosion* are at work, including that of liquid and wind.



3. Opportunities to **Explain** current understanding- (such as an exit ticket, sentence frame, or drawing prompt)
    a. Written Prompt

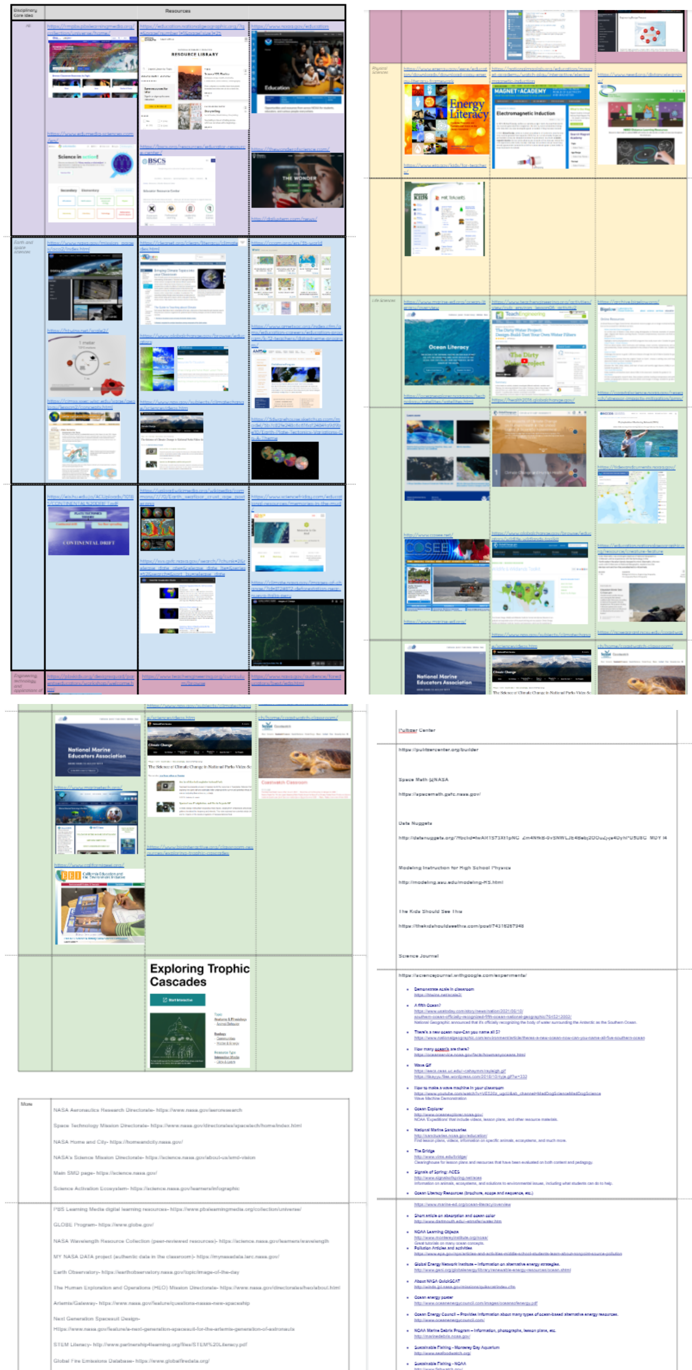
Prompt for explanation	Participant's thinking
Why are there so many different shapes on the surface of Mars?	

    b. This prompt could require many levels of rigor. A sentence frame could be provided to help them get started, or you could make it more difficult by requiring citations from the text.
4. **Elaboration** opportunities to apply new understanding (Such as elaborating on the significance of geological formations and their relation to materials, time, and life.)
    a. Comparison of craters to determine surface materials
    b. Comparison of craters to determine age
    c. Analysis of "squiggles" to determine type of erosion
5. **Evaluation**- assessment of understanding
    a. Participants are given a color enhanced image of the Martian surface.



    b. Participants are expected to outline shapes in the picture. They must then analyze the shape to determine its possible origin and write a corresponding label or question

Appendix C
Resource Document screenshots



Appendix D
Table of Standards

Earth and Space Science	ELA/Literacy	Mathematics	Visual Arts
4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of Cause and Effect Cause and effect relationships are routinely identified, tested, and used to explain change. weathering or the rate of erosion by water, ice, wind, or vegetation.	W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1) W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS1-1) W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS1-1)	MP.2 Reason abstractly and quantitatively. (4-ESS1-1) MP.4 Model with mathematics. (4-ESS1-1) MP.5 Use appropriate tools strategically. (4-ESS2-1)	VA:Re8.1.5a Interpret art by analyzing characteristics of form and structure, contextual information, subject matter, visual elements, and use of media VA:Cr2.3.Ka Create art that represents natural and constructed environments.