EICP Busts Dust By Forming Carbonate Crust

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LESSON DETAILS

Subject Area(s): Earth Science, Environmental Science, Sustainability, Business Management and Finance

Focus Grade Level: High School 11th grade

Grade Level Range: 10th – 12th grade

RESEARCH BACKGROUND

11th grade students at the Tempe Union High School District Innovation Center will be conducting a dust control experiment using Enzyme Induced Carbonate Precipitation technology which relies on a crude extract from Jack Beans. This crude extract contains urease enzyme which induces carbonate precipitation when introduced into a solution containing calcium chloride and urea and when sprayed on soil surface, it has the potential to bind together the soil particles (i.e. bio-cement the soil).

It is the purpose of this research and experiment to help mitigate the wind-blown dust (fugitive dust) on exposed soil at the Innovation Center by applying EICP solution onto these surfaces and recording measurable and observable results over fixed intervals of time. It is the intention of this research to then communicate the results of this dust control experiment to Dr. Hamed Khodadadi Tirkolaei and his research team at the ASU CBBG for data compilation and further collaboration or adjustments for the experiment with the Innovation Center students.

LESSON OVERVIEW

11th grade Innovation Center students will be utilizing a Project Based Learning model to conduct this scientific investigation with the ASU CBBG program for the ***duration of the 2023/2024 academic year***.

The PBL format that students will be utilizing is as follows.

1. Students in group generate driving question for the project.
2. Students generate learning goals.
3. Students generate project summary with facilitator and ASU CBBG approval.
4. State and NGSS standards. Students align ADE standards and follow NGSS standard, NGSS – HS-ESS2-2 analyze geoscience data to make the claim that one change to Earths surface can create feedbacks that cause changes to other Earths systems.
5. Active partner collaboration with ASU CBBG to conduct research, share results and receive feedback.
6. Share with public audience (references included).

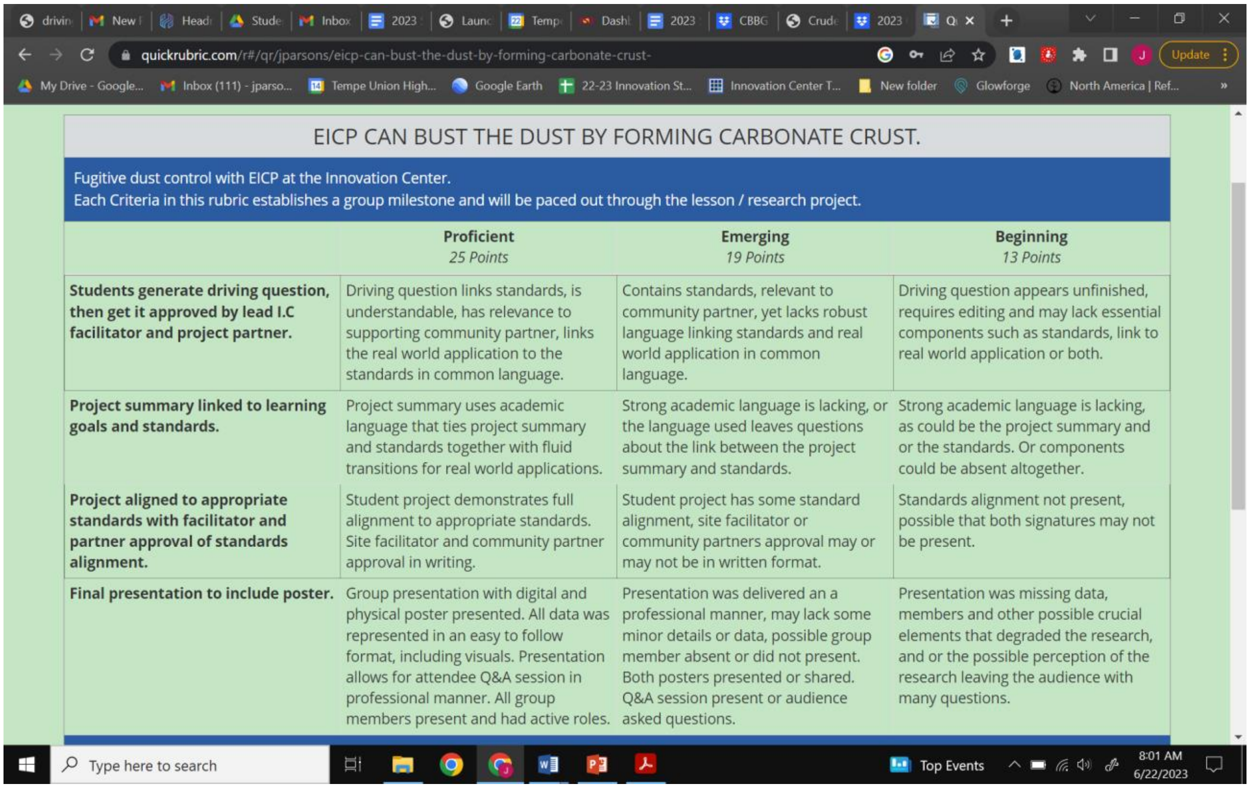
7. Public review and critique held at the I.C conference by invitation, scientific poster included in presentation both physically and digitally.
8. Final dust mitigation implementation plan for Innovation Center North field, possible continuing or research plan could be written pending actual research results from academic year of 2023/ 2024.

Student final grades are subjected to a rubric based grading system that will encompass the details of each individual steps 1-8.

MATERIALS AND EQUIPMENT

- Two separate 2.5 square meter plots of exposed surface soil in north field of Innovation Center.
- Classroom Lab arrangement with workbenches and wash basins.
- General lab apparatuses
- De ionized water
- 4 250 ml beakers
- 4 500 ml beakers
- 2 1000 ml beakers
- EICP solution
- Cheesecloth
- 50 ml syringes, no needles
- Various closed lid containers for EICP storage
- Student laptops
- PI SWERL test at ASU CBBG lab
- Food processor or blender
- Food grade dehydrator
- Innovation Studio (shop) in lieu of Innovation Center lab and ASU CBBG lab for prototyping and creating / modifying apparatuses and repairs of equipment as needed for students.
- Hair dryer
- Leaf Blower
- High Velocity Fan

ATTACHMENTS



EICP CAN BUST THE DUST BY FORMING CARBONATE CRUST.

Fugitive dust control with EICP at the Innovation Center.
Each Criteria in this rubric establishes a group milestone and will be paced out through the lesson / research project.

	Proficient *25 Points*	**Emerging** *19 Points*	**Beginning** *13 Points*
Students generate driving question, then get it approved by lead I.C facilitator and project partner.	Driving question links standards, is understandable, has relevance to supporting community partner, links the real world application to the standards in common language.	Contains standards, relevant to community partner, yet lacks robust language linking standards and real world application in common language.	Driving question appears unfinished, requires editing and may lack essential components such as standards, link to real world application or both.
Project summary linked to learning goals and standards.	Project summary uses academic language that ties project summary and standards together with fluid transitions for real world applications.	Strong academic language is lacking, or the language used leaves questions about the link between the project summary and standards.	Strong academic language is lacking, as could be the project summary and or the standards. Or components could be absent altogether.
Project aligned to appropriate standards with facilitator and partner approval of standards alignment.	Student project demonstrates full alignment to appropriate standards. Site facilitator and community partner approval in writing.	Student project has some standard alignment, site facilitator or community partners approval may or may not be in written format.	Standards alignment not present, possible that both signatures may not be present.
Final presentation to include poster.	Group presentation with digital and physical poster presented. All data was represented in an easy to follow format, including visuals. Presentation allows for attendee Q&A session in professional manner. All group members present and had active roles.	Presentation was delivered an a professional manner, may lack some minor details or data, possible group member absent or did not present. Both posters presented or shared. Q&A session present or audience asked questions.	Presentation was missing data, members and other possible crucial elements that degraded the research, and or the possible perception of the research leaving the audience with many questions.

https://www.pblworks.org/

https://www.quickrubric.com/

https://www.vernier.com/product/anemometer/

EDUCATIONAL STANDARDS

K-12 TEACHERS

NGSS standard, NGSS – HS-ESS2-2 analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earths systems.

Arizona Department of Education state science standards.

All students at the Innovation Center, regardless of grade level, will align their own standards to the project they are working on.

Consider assigning this task in your rubric to your students to enhance their own understanding f what is expected for them to learn, and be taught.

In this context I have included the appropriate ADE Earth Science standard for this application.

HS. E1U3.14- Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.

COMMUNITY COLLEGE FACULTY

LEARNING OBJECTIVES

- Students will be able to create and test an EICP solution to mitigate fugitive dust at the Innovation Center.
- Students will collect fugitive dust data from applying the EICP solution to exposed surface soil.
- Students will collect data from carbonate crust formation on surface soil.

VOCABULARY

Bio- cementation	An ecological process based on microbial induced carbonate precipitation mechanism that results in the deposition of calcium carbonates in surface soils reducing fugitive dust.
EICP solution	A cost-effective plant-based enzyme extract that induces bio cementation of soil and dust particles.
Deionized water	Water that has been purified through the removal of ions.

Fugitive Dust	Dust that cannot be identified coming from a single source, but rather from open fields, roadways and construction sites.
Innovation Center	A brand-new cutting-edge program located in Tempe Union High School District that facilitates PBL learning in a cross curricular environment in a small group setting.
Portable IN SITU-Wind Erosion Lab (PI SWERL)	Portable in-SITU – Wind Erosion Lab- A mobile wind erosion laboratory for field use outside the lab that can determine the effectiveness of the bio cementation process.
Wind Anemometer	A scientific device that measures wind speed made by Vernier corporation.

LESSON PROCEDURE

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This PBL is designed specifically for a high school program and closely follows PBL works model of conducting a PBL. It is likely not plausible for many secondary science teachers to follow this particular PBL framework for an entire academic year as this is written.

What is most likely is the implementation of testing the EICP on exposed surface soils over the course of a couple of weeks in a "normal" classroom setting. The instructions to implement the EICP on exposed soils is as follows.

Once students write a strong driving question that the teacher approves, the next step is to locate and take several samples of exposed surface soil, preferably on the school campus for convenience.

A minimum of 2 separate soil sample locations should be used to test the EICP solution.

At the 2 collection sites, 4 samples should be collected and placed into Ziploc bags to reduce further contamination of the soil to ensure a controlled experiment. The bags should be labeled and dated accordingly for each sample location, students' group, and class.

Each sample should be massed on a precisely calculated scale or balance in the containers that the EICP solution will be applied, it is best to use durable baking pans with sides of at least 2 inches in height.

Once samples #1, and samples #2 are massed, properly labeled and in the experimental containers, the EICP solution can be mixed and applied to one of the samples from each group. One sample should be left as collected from the field sample site to compare mass and calcification using a mild HCI solution to conduct a reaction or "fizz" test.

The test samples that have had the EICP solution applied should be allowed to dry indoors for 3 days to allow the carbonate crust formation to occur. This is a good time to get pictures of each sample post EICP application.

Have students write predictions and hypothesis on what they believe will occur to the soil samples that have had EICP applied to them vs the soil samples that have not as they wait the three days, this should be a component of the rubric they are being graded on.

Other research could be conducted on the hazards of soil erosion, mass landslides and other hazards associated with loose soils in agriculture, civil engineering, freshwater contamination and the affects of global warming and desertification of biomes globally as students wait for the EICP solution to potentially form a crust.

3 days are up, did a crust form on the surface of the EICP applied soils samples. Have students make observations, take pictures and document their observations. Samples could be massed again, and all data recorded for the presentations.

Each soil sample should have a mild hydrochloric acid solution applied to each sample to observe for reactions.

If a soil calcimeter is not available, do your best to remove crust material from the surface of each EICP sample taking care to get the same amount from each separate sample to keep conditions as controlled and variable free as possible and placed in separate beakers, keeping in mind that large quantities of soil are not required for this test. It is more important that the same amounts of soil and HCl solution are applied in containers of the same size, such as 100ml beakers.

Once the HCl solution is applied to each of the 4 samples, two with EICP solution applied and 2 that are bare soil, have students observe and document results. This is a good time to use technology and record video for the digital poster to document the reaction.

Test the samples for wind resistance. Again, this is a good time to have students utilize technology to record video for this part of the experiment.

Vernier makes a great anemometer to calculate wind speed to try to determine at what wind sped particles are being lifted.

A backdrop of paper is hung in a contrasting color compared to the soil color in the background, a grid with specific graduations could be applied to the paper to make further velocity calculations of airborne dust particles from the video recording. Then the wind anemometer is set up using a beaker stand and then connected to a device to record data.

Having all 4 samples set up inline and spaced equally distanced next to each other with video being recorded and the contrasting backdrop in the background.

The wind can be created using a hair drier, leaf blower and or a high velocity fan, with the wind speed being recorded with the anemometer. Every effort should be taken to ensure that all samples and wind creating tools are being held at the exact same distance from each soil sample to create the most similar conditions as possible for each sample.

Once the tests have been made and all results and data have been recorded, it is time to have student groups calculate if their hypothesis was correct or incorrect and if the EICP was effective at controlling fugitive dust on surface soils.

All student groups should now be creating posters, uploading data and evidence as well as preparing the presentations and finalize formal evaluations of their driving question and hypothesis of the effectiveness of the EICP solution on the given soil samples.

Poster presentations are given and evaluated utilizing the teacher made rubric.

INTRODUCTION/MOTIVATION

Students choose the projects they are interested in, and relevant to their course of study based on the classes they are taking at the Innovation Center. A comprehensive list of projects is listed on our Learning Management System.

This particular project will focus on Earth Science standards and objectives at the TUHSD Innovation Center.

In other classes or school sites, short video clips of dust storms, and other pollution and environmental hazards caused by fugitive dust could be displayed and discussed to generate student interest. Other areas to consider are freshwater and soil runoff, topsoil in agriculture and civil engineering challenges.

LEARNING ACTIVITIES/STRATEGIES

Various videos and teacher led scenarios will be displayed to spark student interest in fugitive dust control.

Points base degrading rubric will be utilized for formative and summative assessments.

Productive struggle with strategic questioning and will be utilized to encourage students to formulate solutions on their own as they progress through the PBL.

CLOSURE

All students' groups will create a scientific poster demonstrating the mastery of skills that are aligned to standards. Student groups will also present their data and findings in an open presentation to an audience that will include staff, students, and community stakeholders.

Students are expected to formulate a plan and explain possible long-term solutions to fugitive dust issues in a specific discipline, such as agriculture, civil engineering etc.

ASSESSMENT

The final grade will be assessed through the use of a rubric that assesses each step of the PBL process, to include the scientific poster, both physical ad digital and the presentation.

FORMATIVE ASSESSMENT

The rubric will be written to measure each student's progress based on assigned tasks within each team's experiment. These points will then be calculated at the end of presentations in the summative score for the final evaluative score.

Rubric has been attached to this document.

SUMMATIVE ASSESSMENT

All students' groups will create a physical and digital scientific poster demonstrating the mastery of skills that are aligned to standards. Student groups will also present their data and findings in an open presentation to an audience that will include staff, students, and community stakeholders. Digital posters are expected to have video, pictures and student reflections recorded throughout paced intervals during the PBL process.

For your PBL, a scientific poster in both digital and physical formats may be a viable option to present results, student hypothesis and real-life data that students discovered or gleaned from conducting the experiment to an audience.

Putting the poster together in small groups with specific tasks on research, data and assembling the poster is an effective way to measure each group members progress on assigned tasks as they progress through the PBL, this can be an effective way to pace out the project, or pace accelerated or less motivated students by assigning specific tasks with specific dates and times these tasks are due. A model PBL rubric is demonstrated on this plan, however you can easily create your own to specify tasks per individual.

The cumulative scores using the Rubric as well as the final entry into the rubric is the posters and presentations. Once presentations have been made and all posters have been shared, the instructor can then tally and calculate each individual's performance and or the group based on how the rubric was written and then issue the final summative scores for the EICP application research project.

CONTRIBUTORS

INDIVIDUALS

Mr. J. Parsons – Innovation Center Staff member at Tempe Union High School District.

Dr. Hamed Khodadadi Tirkolaei
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REFERENCES

Khodadadi Tirkolaei, H., Javadi, N., Krishnan, V., Hamdan, N., & Kavazanjian Jr, E. (2020). Crude Urease Extract for Biocementation. *Journal of Materials in Civil Engineering*, *32*(12), 2–11.

Abishek Aryal

Vernier devices

PBL works

Quick rubric

SUPPORTING PROGRAM

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