PROJECT DESIGN: OVERVIEW

Name of Project: Mining Tailing Dam Study		**Duration:** Two weeks
Subject/Course: Engineering	**Teacher(s):** Goeden	**Grade Level:** 11-12
Other subject areas to be included, if any: Physics, AP Environmental Science, Algebra (three other classes that could do this same one)		

Significant Content (CCSS and/or others)

NGSS MS-ETS 1-1
Define the criteria and constraints of a design problem with significant precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and their natural environment that may limit solutions.
NGSS MS-ETS 1-2
Evaluate competing design solutions using a systemic process to determine how well they will meet the criteria and problem constraints.
NGSS MS-ET 1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that could be combined into a new solution to better meet the criteria for success.

We will address all three of these Engineering standards in our task, as we will have to define the criteria and constraints of the task (it is fairly open ended), evaluate the solutions of others, and analyze any data produced from the models that answer the question.

21st Century Competencies (to be taught and assessed) augment list with details

Collaboration—Students will be assigned to specific groups for this task. Within each group, there will be four assigned tasks, and each assigned task must contribute, through collaboration, to the success of the overall task.

- Design Engineer—How would you design it overall. (looking for specific written designs, on paper or computer
- Hydrologist—How will you hold the LARGE amount of water that needs to be held. (looking for either a drawing, a mock-up, or a model of how they will answer this)
- Air Quality Control—What will be done to address excessive dust produced (either a model, a demonstration, a computer design, or written plans)
- Physical Properties—How would you manipulate the properties of the rocks (student needs to present a sample, or a computer site that shows samples)

Each team member has a “secret question” or “question of relevance” that they need to discover, and communicate their answer to their colleagues/teammates. Part of their task includes not only answering their question, but how they assist others in answering/working on their question.

Creativity and Innovation—In this task, we have four different aspects that we are attempting to address. There is more than one defendable answer for some of these aspects, and it will be up to the students to derive a successful answer.

- How will the Design Engineer answer the answer of repose?
- How will the Hydrologist both suggest how the water is held and how do they isolate/prevent contaminants from the dam making their way into the water supply?
- How will the Air Quality Control keep the air from being contaminated with dust? There is an opacity limit which is minimal. Is there a way to keep the dust from dispersing?
- How will the Physical Property study know that the density must be specific. If it is too liquid it won’t stand, too solid it won’t flow.

For each of these questions, there is more than one answer that can be defended (although some are easier than others). How they answer each involves their creativity and innovation.

Standard “canned” answers will be challenged until they can arrive with an innovative answer (or at least something requiring creativity) for any and all of the four “questions of relevance.”

	Communication—Students will be asked first to communicate their results to the classroom in an oral presentation defense. They will also be asked to create an artifact of their own design to articulate their solution to a professional audience. In this, they will need to • Articulate thoughts clearly and effectively (how will they answer the four questions) • Did they communicate not only to inform, but to instruct and/or persuade (the importance of air/water quality) • Utilize multiple mediate/technology (this is tied to creativity). If they are presenting to an authentic audience, they need to formulate appropriately. • Did they communicate well with each other, in multiple environments (class, lab, outside testing) They need to communicate with each other, as each has a question that contributes to the overall design, and they need to communicate with their class and the professional audience (as to both inform and to instruct.)	**Flexible and Self Directed—**As this is an open-ended question, all students will need to be both flexible and self-directed in order to obtain optimal results. In this, they need to • Plan and budget time to meet deadlines (we have a lot to do in two weeks) • Organize time and materials (are they organized?) • Contribute positively to the learning environment (this is more than communication, but real contribution) • Adapt to varied roles (they have a primary role for themselves, but need to help others in their task), schedules, and contexts. • Incorporate feedback from students and teacher effectively • Listen and respect the contribution of others, both in group and in class The issue of self-direction is something that needs to be addressed in a PBL environment. The self-direction allows the other four main p21.org competencies to be tied together.
	Critical Thinking—One of the first aspects of the project is to derive the four factors of relevance. Students will need to derive the angle of repose, issue of water seepage, problem of air pollution, and cost/material usage. In this, could they? • Use logic and reason to derive an answer for each question (did they figure each out without a textbook answer) • Analyze how the four "questions of relevance" actually tie together (the water use ties to physical properties, and the overall design ties to air pollution possible) • Make judgments about what is optimal • Evaluate competing design solutions for benefits and drawbacks • Define the constrains of the problem without having it explicitly being given to them	

Project Summary / SCENARIO / **TASK** (include student role, issue, problem or challenge, action taken, and purpose/beneficiary)	ENGINEERING SCENARIO—Mining Tails Dam Study **Topic*:*** Mining is one of the five C's of Arizona, and easily a vital part of the Arizona economy. In any mine site, the idea of "What to do when you are done with the rock?" must be considered. The main idea is a Tailings Dam Impound. Can a Tailings Dam be created so that it could hold the massive amounts of rock waste, could it hold a reservoir of water (which is required for the mine process) and also satisfy any air and water pollution concerns. There have been at least 221 serious tailings dam accidents worldwide since the advent of extensive mining operations. (http://www.mineralresourcesforum.org/docs/pdfs/Bulletin121.PDF). In our construction, we need to take historical data into account in order to ensure that an accident does not occur here. A good example would be January 2000 in Baia Mare (Romania) which was the biggest freshwater disaster in Central and Eastern Europe. Nearly 100,000 cubic meters of cyanide and heavy metal contaminated liquid spilled into the Lupus stream, reaching the Szamos, Tisza, and finally Danube rivers and killing hundreds of tons of fish and poisoning the drinking water of more than 2 million people in Hungary. Another example occurred in April of 1998 in Seville, Spain. The failure of the Los Frailes lead-zinc mine at Aznalcollar released 4-5 million cubic meters of toxic tailings slurries and liquid into the nearby river. The slurry wave covered several thousand hectares of farmland, and it threatened the Donana National Park, a UN Work Heritage Area. There are many causes for these accidents, but they all can be traced down to one of a few factors. • Inadequate management or oversight • Lack of control of hydrological system (watch the water) • Unsatisfactory foundation or lack of stability of slope • Seepage or overtopping In each case, there must be appropriate risk analysis and a management plan in place to prevent accidents such as this from happening and contaminating the health of everyone in the surrounding area. Consequences of neglect might include • Flooding, wave of slurry • Contamination of surface water • Drinking and irrigation water contaminated (both surface and underground water) • Soil contamination rendering crops unable to grow • Overall food chain contamination In our scenario, we will provide a proper risk analysis by analyzing four selected sources of danger. We will look at the air pollution which results from mismanagement, hydrological considerations, slope failure, and seepage concerns. We will have a goal of mitigating the risk from each condition, and create a barrier of prevention or other means of mitigating the risk so that the local population can live without fear of a tailings dam failure. (information taking from www.unece.org) **INTRODUCTORY PARAGRAPH** **Scenario**: There is a large amount of ore in the Santa Rita mountains worth potentially billions of dollars to the southern Arizona economy. However; we need to design a Tailings Dam impound to complete the overall design of the mining site. We need to consider material consistency, overall structural design, air pollution (dust) concerns, and water contamination in order to complete our overall risk mitigation assessment. Can we design something that satisfies all four of these issues?

Project Summary / SCENARIO / **TASK** This is the second page, continued	**POSE A PROBLEM—one sentence, and pose one question** The Tailings Dam construction is one of the most important risk mitigation issues present in a mining site. Failure to note the four risk issues could result in adverse health catastrophe. Can we construct a Tailings Dam impound to satisfy any question of danger to the surrounding area, whether it be slope failure, water contamination, air pollution, or material efficiency of construction. **TASK:** Make a real problem for students and give them a role. Provide a goal and expectation. You are a group of four that is advising a company on the construction of a Tailings Dam impound in the efforts of risk mitigation and risk management. Each of four "questions of relevance" needs to be addressed or else the health and safety of the local community might be in potential danger. For each group, I will have • Design Engineer—Explains the overall design of the structure (looking for specific designs on paper). • Hydrologist—How will you hold the LARGE amount of water that needs to be held? • Air Quality Control—What will be done to address excessive dust produced? • Physical Properties—How would you manipulate the properties of the rocks? (too dense wont flow, too loose won't stand) I will have a syllabus/scoring guide available for the students as well, to demonstrate the expectations for each in a more illustrated manner. They will have a goal and a timeline. Their ability is theoretical in nature, but must have a reasonable design (no space alien technology). Remind them about dust, water usage, water seepage and contamination, physical structure, and angle of repose. According to the scoring guide • On a scale of 1-5, is the answer valid within the realm of expectation? • On a scale of 1-5, have they made a reasonable financial determination and/or argument? • On a scale of 1-5, have they effectively shown how the environmental impact would be minimal? • On a scale of 1-5, have they shown if the public would be okay with this? **OTHER THOUGHTS TO CONSIDER (additional notes)** • The mining process uses a LOT of water, and they need a place to store/stash it • If you are not careful, it will give off a lot of dust in violation of air pollution controls • If you are not careful, you will have water contamination of the local aquifer • How do you address the concept of density The purpose of each question is a state of feasibility. If one of the questions fails, then there will be no tailings dam. • If you do not have a place to put water, then there is no process • If you do not address the angle of repose, it cannot hold anything, and you are ineffective with time/space • If you violate air pollution policies, you will be shut down • If you violate water pollution, you will be shut down • If your density is wrong, the entire structure collapses The overall design is to produce an optimal structure that answers each question of relevance, and demonstrates feasibility within the constraints of Engineering.

<table>
<tr><td>Driving Question /s (essential questions)</td><td colspan="2">Large tailings dams, which are built to contain waste, must stand in perpetuity, as construction or maintenance failure can lead to long-term environmental damage with huge cleanup costs. This could lead towards health issues for all members in the surrounding ecosystem (plants, animals, and humans). How can a tailings dam be successfully created and maintained so that all environmental risk factors are properly addressed in a financially feasible, structurally sound, and politically viable manner?</td></tr>
<tr><td>Entry Event</td><td colspan="2">As this project centers around four “questions of relevance,” I would have a four part set entry event to give them the pieces of the puzzle. These are more demonstrations than labs, meant to observe, and whet the appetite to learn.

a) First, show them one side of a dam, and what happens due to water (perhaps a youtube video or a model mockup)
b) Second, show them outrageous dust (air pollution failure) and why should that be avoided at all costs
c) Third, show them different slurries at different densities, why do some flow faster then others
d) Finally, illustrate for them overall design

Once that is done, lead them to the idea of a mining site (showing images on screen of Sierrita from above). Have them look at the Pit. Eventually, move over to the Tailings dam, and see if they can tie the four mini demonstration to the Tailings dam. Finally, give them the question “Can you construct one of these taking into account every factor?”</td></tr>
<tr><td rowspan="2">Products</td><td>Individual:
• Written evaluation by each team member for their specific role towards the final project
• Written evaluation of the team media project
• Anonymous survey of the rest of the team’s performance in the task, looking for the 21st century core competencies.</td><td>Specific content and competencies to be assessed:
• Did each student successfully address the question posted to their specific job responsibility (content)
• Did each student collaborate with the group and communicate their thoughts reasonably and effectively
• Was each student’s solution reasonably innovative, or was it textbook minimalism
• Was each student self-directed, as indicated by the group
• Was each student able to articulate their thoughts on their specific question (communication)</td></tr>
<tr><td>Team:
• Media presentation of the team’s choice (recorded powerpoint video, physical simulation and discussion, tri-board)</td><td>Specific content and competencies to be assessed:
• Were all four main questions of relevance addressed? (content)
• As a group, how did they communicate their ideas?
• Was their answer both innovative and effective?</td></tr>
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PROJECT DESIGN: OVERVIEW

Public Audience (Experts, audiences, or product users students will engage with during/at end of project)	As a culmination, students will be asked to create a media-based artifact that shows their understanding of their task • Their first audience is the classroom. They will be asked to present their design of innovation to the classroom for their feedback. In this case, students will be given the chance to evaluate competing designs in hopes of determining an optimal solution. • The second audience will be our site and district administration. They will be invited to observe, along with out community outreach coordinator to help tell our story and finding to the community. • Our mining audience will be part of our authentic experts. I have already secured consent to ask 4-5 miners to come into class, discuss what they know about the topic, and asses the positives and constructive improvements that can be made from the student's designs. This authenticity will demonstrate the realism desired in this project. • To represent the environmental side, I will solicit the assistance of Arizona Department of Environmental Quality that has a presence in Tucson. They can objectively assess if a tailings dam would satisfy any environmental concerns.
Resources Needed	On-site people, facilities: • Administration to help judge the final project/presentations • Computer lab days to research previous Tailings dam failures to assess possible issues and constrains • Computer lab time to research air pollution requirements and constraints • Library time to read and research questions of relevance for our task • Science lab time to test water capabilities (my current room is carpet and does not take to water well)
	Equipment: • A scale sensitive enough to determine the mass for the density calculations • A means of determining volume to have density • Computers/internet for research capabilities • Water basin to test water capabilities • A fan to demonstrate heavy wind (for pollution/dust)
	Materials: • A variety of rock samples to have for students to determine optimal density/composition • Demonstration materials (various minerals) to show students what Tailings are comprised of • Water or a water source • Adhesive (or something to simulate sticking rocks) • Wood and/or cardboard to help with tailing dam perimeters/structure

	Community Resources: Websites for study • http://www.wise-uranium.org/mdaf.html (to show tailings dam failures) • https://www.google.com/earth/ (to see FMM Sierrita dam from above) • http://www.epa.gov/oaqps001/permits/ (information on how restrictive air permits and water restrictions really are) • http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/tailings.pdf For ideas on how to construct tailings dam Community Experts • Students will be given one chance to ask the experts at the min questions regarding their task. We will videotape, type, or record any questions that students might have, send them to the mine, and ask the training department to videotape any answers. It will bring a real authenticity to it. • I will endeavor to bring a community pollution expert in as well to address pollution concerns, and lend further authenticity.			
Reflection Methods (Individual, Team, and/or Whole Class)	Journal/Learning Log Students will be asked to write daily in a learning log so that they will reflect on what they have learned. Each day will have a specific "mini-task" attached to it, and by reading their reflection, I will be able to assess what the student has learned.		Focus Group Our students will be given one chance to ask miners a question regarding their topic or challenge. While they are not an "official focus group," they will be able to provide feedback (from an outside perspective) for their project and how it is proceeding. In addition, they will get the opportunity to address an expert from the environmental community to ensure that their answer is validated by environmental concerns.	
	Whole-Class Discussion After each presentation at the end of the unit, I will engage the students in Socratic discussion in the hopes of eliciting answers to our main objectives. Can they evaluate competing designs to the same question in the hopes of determining which is "optimal."		Fishbowl Discussion Over the two week's time span, students will be given two specific instances where they can ask/interview others in the room to gather ideas and competing thoughts.	

	Survey Students will be given a pre and post survey to demonstrate what they have learned within this task. By comparing the two, they will reflect on what they have learned with this task.		Other:	

Notes: Reflection is a key part of our Project Based proposal. Until the project is done, the best learning is done through the reflection of others. Group members reflect on the process in the hopes of improving their own process. The focus group of the mine provides a great opportunity to have students learn by asking questions. They will also have a chance to ask someone from the environmental expert community to justify "the other side" of the argument. This also provides me another means of informal "check-for-understanding" of their progress when they ask questions of their experts.

P R O J E C T   D E S I G N :   S T U D E N T   L E A R N I N G   G U I D E

Project: Mining Tailings Dam Study

Driving Question: Large tailings dams, which are built to contain waste, must stand in perpetuity, as construction or maintenance failure can lead to long-term environmental damage with huge cleanup costs. This could lead towards health issues for all members in the surrounding ecosystem (plans, animals, and humans). How can a tailings dam be successfully created and maintained so that all environmental risk factors are properly addressed in a financially feasible, structurally sound, and politically viable manner?

Final Product(s) Presentations, Performances, Products and/or Services	**Learning Outcomes/Targets** content & 21st century competencies needed by students to successfully complete products	**Checkpoints/Formative Assessments** to check for learning and ensure students are on track	**Instructional Strategies for All Learners** provided by teacher, other staff, experts; includes scaffolds, materials, lessons aligned to learning outcomes and formative assessments
(individual **and** team) Students will be asked to create either a model, a media simulation, a tri-board presentation, or any other means of a physical or electronic artifact that shows answering the four questions of relevance. Air Pollution Water pollution Structural Issues Design structure	NGSS MS-ETS 1-1 Define the criteria and constraints of a design problem with significant precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and their natural environment that may limit solutions.	One of the first checkpoints will be the design phase. Students will be asked first to compose a rough draft of their thoughts onto paper for their design. This design will be evaluated first by group peers, then other groups, and finally by the instructor.	• Model design phase with a similar scenario (but nothing that can be copied) • Socratic evaluation of obviously failed constructions (taken from internet) • Scaffold learning from Environmental class and Environmental sections in our Engineering class • Minor formative assessments to judge progress within the criteria and constrains of the challenge
	NGSS MS-ETS 1-2 Evaluate competing design solutions using a systemic process to determine how well they will meet the criteria and problem constraints.	Both at the design phase, and the presentation phrase, students will be asked to evaluate every other group, and they will give constructive feedback on their designs in the hopes of determining optimal design.	• Modeling approach, I have a poorly done creation so that students can take the rubric and see how it meets criteria. • Fishbowl—students will evaluate each other through discussion. • Expert—miners will be able to comment on competing design solutions in the hopes of helping students.
	NGSS MS-ET 1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that could be combined into a new solution to better meet the criteria for success	If someone builds a model capable of analytical testing, then we will perform quantitative tests to analyze. If this is not feasible, then I will provide the class with simulated data in the hopes of a cross-design analysis.	• Demonstration of lab activity and lead class in analysis of results • Periodic formative assessments to show they can properly analyze data • Align a mini lesson to show how and why analysis (both similarity and differences) are needed in lab study

	21st Century Competency—Critical Thinking • Reason effectively • Analyze parts of a whole • Make judgments and decisions	During the conclusion of the design phase, we will have a checkpoint where the group articulates "Are the four questions of relevance" answered in a collaborative and cohesive manner?	• Rubric—they will have means of officially answering if the four questions of relevance are answered • Model—I will show them an example of how to analyze parts of the whole in something similar
	21st Century Competency—Communication • Communicate clearly • Collaborate well with others • Articulate thoughts clearly	As an individual, did the student communicate their thoughts onto paper onto a complete and consistent basis? At the end of the task, do the anonymous surveys show that everyone worked well together, sharing ideas and thoughts	• Modeling proper communication strategies • Passing out examples of sample articulation onto paper • Reminders via proximity of proper communication
	21st Century Competency—Creativity and Innovation • Use wide range of ideas • Demonstrate originality • Implement innovations	Students will be given at least two opportunities to brainstorm outside of their group. At each point, I will check to see if they are innovating in their approach. My focus group at the end of the unit will be able to help judge creativity and innovation of the approach as well.	• Leading class discussion at regular intervals to socratically infer original thought (questions without stating) • Promoting the sharing of ideas in order to spark innovation (also through example)