

Mineral Mayhem: Using Engineering to Teach Middle School Earth Science (Resource Exchange)

Mrs. Holly Miller, Riverside Intermediate School

Holly Miller is a 6th grade STEM teacher at Riverside Intermediate School. She is the recipient of the Mike Neden STEM Champion award, a state finalist for the Presidential Awards for Excellence in Math and Science Teaching, and the 2016 Teacher of the Year at her school. As an International STEM Fellow, Holly travelled to China in 2016 to observe STEM practices.

Prof. Tamara J. Moore, Purdue University, West Lafayette (College of Engineering)

Tamara J. Moore, Ph.D., is an Associate Professor in the School of Engineering Education and Director of STEM Integration in the INSPIRE Institute at Purdue University. Dr. Moore's research is centered on the integration of STEM concepts in K-12 and postsecondary classrooms in order to help students make connections among the STEM disciplines and achieve deep understanding. Her work focuses on defining STEM integration and investigating its power for student learning. Tamara Moore received an NSF Early CAREER award in 2010 and a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2012.

Mr. Aran W. Glancy, University of Minnesota, Twin Cities

Aran Glancy is a Ph.D candidate in STEM education with an emphasis in Mathematics Education at the University of Minnesota. He has experience teaching both high school physics and mathematics, and his research focuses on supporting mathematics learning, specifically in the domains of data analysis and measurement, through STEM integration and engineering. He is also interested in mathematical modeling.

Emilie A. Siverling, Purdue University, West Lafayette (College of Engineering)

Emilie A. Siverling is a Ph.D. Student in Engineering Education at Purdue University. She received a B.S. in Materials Science and Engineering from the University of Wisconsin-Madison, and she is a former high school chemistry and physics teacher. Her research interests are in K-12 STEM integration, primarily using engineering design to support secondary science curricula and instruction.

Siddika Selcen Guzey, Purdue University, West Lafayette (College of Engineering)

Dr. Guzey is an assistant professor of science education at Purdue University. Her research and teaching focus on integrated STEM Education.

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Elizabeth Suazo-Flores, Purdue University, West Lafayette

Elizabeth Suazo-Flores is a Ph.D. candidate in Mathematics Education at Purdue University. She is a former secondary mathematics teacher graduated from a Chilean university. Elizabeth's research is centered on mathematics teachers' knowledge. Currently, she is exploring a middle school mathematics teacher's practical knowledge using personal experiential research methods.

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Project Description

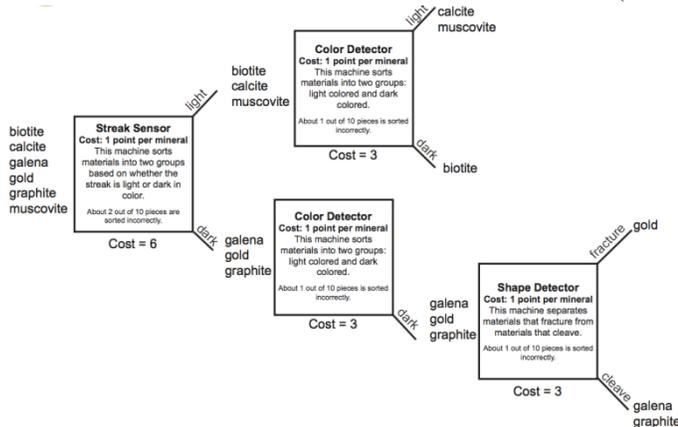
The EngrTEAMS project has been developing a suite of 13 integrated STEM curricula for grades 4 – 8. The curricula are hands-on engineering design challenges that integrate mathematics and science grade-appropriate content, mapping to Next Generation Science Standards for engineering and discipline-specific standards. Each unit was inspired by a team of teachers and developed in conjunction with members of the EngrTEAMS project. The design projects in each unit vary in context and in terms of the mathematics and science concepts needed to create an adequate solution. Yet, within all the variation, each unit is an authentic engineering design challenge. Each unit has gone through an extensive design research cycle to ensure its quality.

Unit Description

This eight-lesson, 15-day unit is designed for middle school students to learn about mineral properties and identification, as well as engineering design. The unit begins by introducing a real-world problem, which is that a cargo train has derailed from its tracks and spilled the minerals it was carrying into a lake. Taking on the role of engineers, students are tasked with designing a process to sort these minerals. They learn about science content related to mineral properties, how these properties can be used to identify minerals, and the value of non-renewable resources. Additionally, students learn about the physical property of density, including how to calculate and represent mass, volume, and density in different ways. They then generate design solutions, making decisions using evidence-based reasoning with support from this science and mathematics content, as well as the criteria and constraints of the engineering problem. Students also strengthen their communication skills by creating a presentation to explain their process and justify their decisions, with the aim of convincing a client that their process is the best option.

Next Generation Science Standards (NGSS) Addressed: 5.PS1.3, MS.ETS.1–MS.ETS1.4

Common Core State Standards – Mathematics (CCSS-M) Addressed: 8.EE.B.5, HSS.ID.C.7



Above Discovering Density lab
Left Example of Mineral Sorting Flow Diagram



Unit Summary

Lesson	Summary
Lesson 1: Off the Rails	Students are introduced to the engineering problem by reading a client memo, which orients them to the problem of sorting minerals reclaimed from a lake after a train accident. They are introduced to the engineering design process and conduct research on the importance of minerals as a non-renewable resource.
Lesson 2: Let's Sort It Out	Students work in small groups of three to sort a set of minerals according to their similarities and differences and identify possible ways of distinguishing between minerals. They learn about the mineral identification methods used by geologists.
Lesson 3: Which Mineral is That?	Working in teams, students work through a series of stations to measure the physical properties of minerals. They learn about mineral hardness, streak, shape (cleavage/fracture), luster (metallic/glassy/dull), magnetism, and color.
Lesson 4: Discovering Density	In their teams, students investigate the relationship between mass and volume for a material. They measure the mass and use water displacement to determine volume of mineral samples. They create a scatterplot of mass vs. volume, draw a line of best fit, and calculate the slope of the line to discover the density of the minerals. Students also use the density formula to calculate densities of additional minerals.
Lesson 5: Go with the Flow	Students revisit the criteria and constraints of their engineering design challenge. They are introduced to the various machines that will be available for their use, how the machines work, and their associated costs. Students are given a sample process flow diagram that shows a process that could be used to sort a set of minerals. They learn how to interpret the diagram, calculate the cost of the process, and determine the value of the minerals that are sorted. This process is not optimized, so students have an opportunity to investigate possible improvements.
Lesson 6: Engineering Design Challenge	Teams are given the names of a new set of minerals to sort and identify. They work together to create a process flow diagram that shows how the minerals could be sorted. They justify each choice and evaluate their process design based on the criteria of the engineering problem, including cost of the machines they use and the value of the minerals they sort.
Lesson 7: Process Redesign	Student teams find out that plastic and wood are also mixed in with the minerals being recovered from the lake. Given the new constraint, they modify their previous process flow diagram to separate the plastic and wood from the minerals.
Lesson 8: Convincing the Client	Having optimized their process designs, teams create presentations about their sorting processes. They justify their choices and try to convince the client that their process is the best option. Students also draft a memo to the client summarizing the design and their arguments in favor of it.

