Day in the Life of Materials Engineer

Author's Name: Danielle Martin **Coach Name:** Debra Dimas
Host Organization: Lockheed Martin Space, PMP Labs, Sunnyvale;
Mentor: Sarah Mieding
ETP Type: Traditional / Classroom
Subject/Grade: Makerspace Elective (Engineering Basics) and/or Intro to CTE Engineering (Bridge Fall 2020) 9-12th
School: East Palo Alto Academy (Sequoia Union HSD)

Abstract (~150 words)

For two crazy months in the summer of 2020, Miss D was an Ignited Teacher Fellow at Lockheed Martin, Space's PMP Lab. Mechanical & Structural PMP Engineering at LM Space encompasses Mechanical and Structural Parts, Materials and Processes including thermal materials, surface treatments and coatings, mechanical piece parts, and contamination control engineering for satellites, rockets, and other space instruments. – East Palo Alto Academy Bulldog makers certainly don't do this kind of work every day in the Dream Lab, right? WRONG. Since I have never been a professional engineer (nor attended a classic engineering educational program), my primary Ignited fellowship goals is to document then share the professional atmosphere and practices of an engineering shop or lab, and make connections around how we operate and learn in the makerspace classroom (Dream Lab).

By reviewing a typical quality-controlled test cycle for LM Space PMP Lab project, learners in this lesson will visualize the steps a materials engineer takes to consider the structure, properties, processes, and performance of materials. Teams (or pairs) of learners will then answer a mini challenge to develop a simple composite, fused fabric, then test a new material to solve a more everyday problem than space flight, such as being waterproof or not ripping under weight of a common grocery item.

NOTE: This lesson is 10 instructional hours inside of a larger Makerspace elective project-based learning unit (see more in Unit outline).

Focal Content & Supporting Practices

CA CTE Engineering & Architecture Anchor Standards

5.3 Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.

CA CTE Engineering Technology Pathway Standards

B5.5 Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.

B8.3 Perform tests, collect data, analyze relationships, and display data in a simulated or modeled system using appropriate tools and technology.

21st Century Skills and Applications (1 - 2)

21st Century Skills in Context

Problem Solving
- Secures additional relevant information regarding problem and generates multiple strong alternatives for solving it
- Uses prototypes, simulations, or other methods of testing and iteration to arrive at best solution

Flexibility and Adaptability
- Works effectively in climates of constant ambiguity, diverse viewpoints, and changing priorities
- Views most challenges as opportunities for exploration and development rather than as hurdles or setbacks

By profiling how different parts of the PMP Lab work together, students will explore a real-world example of systems thinking, then use a framework to then analyze how various components interact with each other to produce outcomes in a complex work environment. When they participate in mock role plays or documents stories of the day in the life of a materials test or development, they will highlight dependencies, collaborations or failure analysis as a positive outcome of a malfunction.

Measurable Objective(s)

By the end of this lesson, learners will be to:

1. State what materials and mechanical engineers do to design and test common materials.
2. Research, analyze, design then test possible solutions to materials testing challenges such as simulating the conditions a product will face during its life span in a timely and cost-effective manner or acquiring accurate and reliable data.

Fellowship Description (300-500 words)

My Fellowship project at Lockheed Martin Space Parts, Materials, Process (PMP) Lab Sunnyvale will include tasks such as:

- Updating internal documentation, including each lab's Capabilities one-sheets and converting to Share-point searchable access.
- Performing materials tests in many of the sub labs or updating documentation around validating vendor testing reports
- Document a "day in the life" of an internal customer Engineering Development Lab project, including how they collaborate with all the other PMP local sub labs, in order to develop then train LM employees on how to lead maker learning related to their expertise during future volunteer opportunities
- Support a quality control audit

The skills used in my Fellowship project will include:

- Research
- Test
- Analysis
- Development documentation

The types of careers related to your Fellowship project:

- Aerospace, focused on outer space, engineering
- Materials engineering or science
- Mechanical engineering
- Quality Assurance

The work being done by your Host Organization and/or Mentor:

- Training me (or coordinating shadowing of each sub lab's leads, on how to run physical and virtual vendor traveler data report testing)
- Review of all the different standards, measurements and specifications necessary to ensure quality materials
- Training in safety and rigorous laboratory documentation

Fellowship Connection to School/Classroom (300-500 words)

For EPAA's new CTE Engineering pathway course, Intro to Engineering, I will need to just tease some of the career path exploration the students will do in the second semester in the Foothill College dual enrollment class. I want to connect to the Engineering Anchor Standards that align to the school's Bulldog Way skills, specifically grit or persistence while also adapting to changing and varied roles and responsibilities.

During my quick weeks at LM Space, I'm getting quickly plunged in the language, vocabulary, and terms that my engineering tech students will have to start adopting as they articulate their design processes. I'm particularly interested in simulating development of composite materials which are synthesized to meet some specific demand. To perform performance tests, we could simulate mechanical testing such as tensile, compression, flex, peel, hardness, burst, torque and fatigue, using the visual thinking processes of sketch noting or creative labeling to identify and define terms in context of real world tests or innovations based on existing common supplies available in at-home learning contexts.

Finally, as learners perform tests, collect data, analyze relationships, I hope to give real world examples about how materials engineers collect and display data in a simulated or modeled system using appropriate tools and technology for problem solving.

Host Organization Engagement (~100 words)

My primary goal of the Ignited Fellowship was to capture then tell the story of how the makerspace, digital fabrication, and engineering skills my students learn and perform every day in the Dream Lab are just mini versions of what real aeronautics and materials engineers do SAFELY every day to build satellites and rockets at Lockheed Martin. My hope is to narrow down to a few key skills, processes, and tools, then show how a few key PMP Lab engineers and tech's use them to complete a test or engineering development project. My mentor expressed any activities and lessons I develop would be interesting to her staff as far as hosting future Bring Students to Work and other in-school volunteering opportunities. We hope I could test them with my students first then share and maybe train LM Space staff on how to facilitate with other students.

Virtual Mentoring

During my facilitation, I aim to have the PMP Lab Engineers virtually volunteer mentor, by

visiting my classroom (and if possible, with security concerns maybe) give some virtual tours to students of their labs. I'll also have the students mirror these processes with smaller materials tests or development projects, then invite the PMP Lab engineers to give feedback on prototypes or final iterations. I will also adapt some of the PMP Lab safety training for my students, especially around making connections to OSHA regulations in the real labs. I hope to mirror some of the internal customer lab Capabilities Sheets in our Dream Lab, by having students create their own versions for tools or projects in our makerspace. If PMP Lab staff are willing, I hope to have them interact directly with students around mentoring around projects but also give them a chance to ask about their educational paths and lessons learned.

DIY Materials Engineering Maker Project Toolkit

Since my district has elected to start the 2020-1 school year totally distance learning, I'm going to pivot this lesson further by pre-recording interviews with LM PMP Lab staff exploring the materials engineering processes at LM Space as case studies. Based on a working script, I'll capture audio, video, and still digital photos, as well as produce sample tests for experimenting with materials science with everyday recycled materials. (This script might also be helpful to other teachers hoping to facilitate this learning, perhaps finding their own volunteer expert mentors locally to support the student design cycles as we intend to do at LM+EPAA). Then we will prototype the projects in a "maker-thon" during my last week of the Fellowship. We will test uses of these materials internally at EPAA and LM Space over the course of the next school year. I will leave the documentation at LM then cycle back by end of the first semester to compare notes on facilitation.

Supply List

Chromebook - headphones/microphone + stable and strong internet connection

Makers Build Power Self Kit - working with RAFT San Jose to get these sourced...might include:

- Scissors, Canary Knife (cutting cardboard)
- Gloves / Goggles
- Pencils
- Hot Glue Gun
- Sewing Basics Kit
- 3 kinds of adhesive tape and glue
- Cleaning supplies
- Paper Microscope (Foldscope)

For Fused Fabrics:

- Household Iron
- Recycled plastics
- Wax or parchment paper

Instructional Plan

Prerequisite: Units on defining makerspace and safety.

Prep:

- Pre-recorded video interviews or day in the life of a materials test videos with 2-3 LMSpace PMP Lab or other Materials Engineers/Tech's (see script for LM version as reference)
- Complete and distribute distance learning makerspace in a box kits, including paper copies of worksheets

PROCEDURE - Wk 2-3 (2 synchronous then 1 independent, then 1 paired assignments)

Hr	5Es	Facilitation	Tools

.10	Engage	Lesson / Unit Opener
		• Prior Knowledge = #?oftheDay
		  ○ Watch - The Different Types of Adhesives
		  ○ https://www.youtube.com/watch?v=6qutTkJ4rO8 then Name 5 kinds of adhesive material around you right now(at home or where-ever you do schoolwork)
		  ○ EXTRA- Reference https://www.explainthatstuff.com/adhesives.html
			Stormboard or Canvas Quiz/Poll
			
			YouTube

0.15		• Hold class meeting video conference (that is then recorded and posted) to review lesson outline & Essential Questions:
		  ○ How might the composition and performance of the materials a maker chooses affect success and quality?
		  ○ How do materials engineers design and test materials such as adhesives and composites?
			UnHangout or Zoom for synchronous

0.25	Explore	DEEP DIVE: Day in the Life of a LM Space PMP Lab Materials Engineering test/project - Students watch pre-recorded video profiles (see script) real life engineers/tech's reviewing 2 examples: 1. Designing, prototyping then testing a composite material (for heat resistance, strength, or adhesive) 2. Verifying adhesive and/or attachment strength - producing lap shears then mechanical testing • alternative ideas from PMPLab ○ a Failure test where you slice a component to discover something you	Posted videos on Canvas or YouTube

		can only know if you look/measure inside small things; could mirror with a simple dissection then microscope ○ witness plates from Contam Lab ○ Verifying then re-designing cleaning oil (Chemistry)	
.75		Live "Meet the Engineers" video chat Discuss lesson's essential questions and extend to discuss: ● How might unique contexts like SPACE constrain solutions, especially around composition, strength and durability? ● How might it constrain development processes (simulating weightlessness and space temperatures) or high risk of failure?	Zoom
0.1		Exit Reflection - go back to #?oftheDay Stormboard; add comment on your own or someone else's examples connecting it to one idea or lesson learned of the PMP Lab materials engineers.	Canvas Discussion or Stormboard
0.5	Explain	Students watch video then answer questions that tease out major new vocab on steps a materials engineer takes to consider the structure, properties, processes, and performance of materials Live Hangout (then recorded video) of demo of how to fuse fabric at home	Synchronous Options ● Live demo based on HGTV or Organic Authority Tutorial Asynchronous Options ● Videos from PBS Making Stuff on Materials Science concepts ● BrainPop on Plastic
1	Elaborate	*Individual Assignment:* DIY Fabric Composite - (see Exploratorium Fuse Fabrics or Art of Tinkering Fuse Your Own Fabrics p 185-189)...steps may include: 1. Research prototyping textiles (especially from recycled materials) 2. Gather your raw materials 3. Choose design challenge constraint - waterproof, heatproof, tensile strength 4. Fuse your fabric using a household iron (review	Handout: http://www.agencybydesign.org/sites/default/files/AbD%20Materials%20Exploration%20.pdf Shared Personal Copy of Engineering Journal template

		safety guidelines sheet/video) 5. Sew something functional out of it (bag, mask, hat, sling, etc.) 6. Reflect - create then share (to a common Google Drive Folder) a Parts, Purposes, Complexities thinking routine journal entry sketch to document process Complexities OBSERVATION Questions (to be answered in Engineering Journal entry): • What the materials can do, how they move and take shape differences between materials and how some work together • Different ways to attach materials and what types of fasteners work well • How rigid or flexible the materials are • How to work 2 dimensionally or 3 dimensionally with materials • Other observations	
1		Pair Challenge - Test Your Composites - ○ describe properties or your partner's fused fabric composite (use homemade paper microscope, mobile camera) ○ then test strength at home – use DIY Spoon Drop test in p 5 of PBS Making Stuff Activity Guide; other options include: ■ use other homemade scientific tools like paper microscope; include notes on ideas from engineers like LM PMP Lab Manny, Keith, and Rod about using can of soup as weight for tensile test ○ Document test results as entry in Engineer Notebook ■ EXTRA – how to keep a Engineer Notebook like a real life materials engineer, including page numbering, neatness, indexing, etc. (adapt your own version of these teacher created PLTW slides) ○ EXTRA: Consult with LM Space Materials Engineer/Tech either before prototyping and/or during testing ■ Message to students: To get this support, email one of these LM PMP Lab engineers, including a draft of your Engineering	NOTE: If can't expect all students to have irons at home, or drop off or swap projects; Offer alternative to test their own or engage someone in their household / social distance bubble if swap not feasible. OR offer socially distant "fusing clinics" where teacher sets up materials and tools in makerspace to attempt testing.

Notebook page documenting your project. He/she will respond by email and setup a time to chat with you. Make sure to give a professional amount of turn around time (aka don't wait until the night before the due date!)

- Message to LM mentor: Thanks for volunteering to mentor my Makerspace elective students. Attached is a description of the assignment from our online platform, and here's a list of prompt questions you might ask… start by explaining that materials engineers are always looking for ways to make stronger materials.
    1. Why is knowing the strength of a material important? (To determine the best way to use it and how safe it is.)
    2. What could you use the strongest material for? What about the weakest? (Accept all answers.)
    3. What other types of tests might materials scientists do on different materials?
    4. (Compression strength tests—squeezing or crushing a material until it breaks; Tensile strength tests—pulling a material apart until it breaks; Deformation tests—stretching or bending a material until it will not return to its previous shape)
    5. What are some other ways you can make a material stronger? (Add layers, change the shape, or change the structure, for example, by folding, weaving, or bending, like corrugated cardboard.)
- (from PBS Making Stuff Activity Guide)

0.25	Evaluate	Students individually submit a Final Engineering Journal Entry: ***Email to a Materials Engineer*** Update PPC worksheet after testing process & review in-progress notes 3 paragraph or 5 minute video reflections (prompt questions) When I look back at my entries from this lesson, I... See - Describe what a materials engineer does; also include Common ideas, questions, observations Think - such as making guesses or asking more questions on why fused fabric or composites worked or failed Wonder - offering inspiration around using recycled materials or other questions about how materials engineering affect everyday maker and/or aerospace designs?	Parts Purposes Complexities Grid template Flipgrid
	Extend	Friday Live Open Make Coaching Sessions or Making Clinics in person Optional Virtual Tours of PMP Labs (synchronous Zoom chats or pre-recorded) **Battle of the Beams -** Students explore the properties of composites to see how different materials and processing techniques affect material properties and performance. They create beams using Laffy Taffy and water, along with options for reinforcements (pasta, rice, candy drops) and fabricating temperatures. Teams compete for the highest strength beam, measured by flexure strength three-point bend tests and calculations. Watch this activity on YouTube Play What's This Stuff game on PBS Learning: http://d3tt741pwxqwm0.cloudfront.net/WGBH/nvms/nvms_int_makingstuff/index.html	(optional Zoom meeting plus extra kit to be picked up ahead of time) *How can students continue their understanding? What else can students do to dig into this topic?*

Formative Assessment(s)

#?oftheDay then Exit Reflect questions or journal entries

E-Engineering Notebook (Journal)

1. Convert paper version of Engineering Notebook on Amazon or Matt Miller's GSlides into your own template, then give prompts through Canvas
2. AbD thinking routine based prompt questions per 4 main sessions - 1 before, 2+3 during, 4 after hands-on builds &b tests
3. entry checks by peers and/or LM Space volunteer mentors

Summative Assessment(s)

Parts, Purposes, and Processes reflective journal about their team/pair materials test - *Parts Purposes Complexities Grid template*
https://docs.google.com/drawings/d/15SJb3NQIQQ4ZELcXlQMZnj6-g6ktctlf4_S7bLPIIf0/edit?usp=sharing

E-Engineering Notebook entry checks by facilitator - adapt this rubric
https://www.northernhighlands.org/cms/lib/NJ01000179/Centricity/Domain/282/Engineering%20Notebook.pdf

Assess using adaption of Digital Harbor Maker Project Rubric -
https://blueprint.digitalharbor.org/maker-project-rubric/

In-Person Enhancements

Group builds especially around plastic fusing iterations

Peer Gallery Walks

References

Citations:

Digital Harbor Foundation. *Maker Project Rubric*. DHF Blueprint. https://blueprint.digitalharbor.org/maker-project-rubric/.

Engineering Notebook - Northern Highlands Regional HS ... https://www.northernhighlands.org/cms/lib/NJ01000179/Centricity/Domain/282/Engineering%20Notebook.pdf.

Exploratorium. (2019, November 18). *Plastic Fusing*. Tinkering Studio. https://www.exploratorium.edu/tinkering/projects/plastic-fusing/.

Fun Look at Material Science - Lesson. TeachEngineering.org. (2020, February 25). https://www.teachengineering.org/lessons/view/uoh_matlsci_lesson01.

Harvard Graduate School of Education. *Agency by Design*. Explore the Framework | Agency by Design. http://www.agencybydesign.org/explore-the-framework.

Harvard School of Education. *AbD Materials Exploration 06.25.18 - Agency by Design*. Agency By Design. http://www.agencybydesign.org/sites/default/files/AbD%20Materials%20Exploration%20.

pdf.

IEEE. *Materials Engineering*. TryEngineering.org. https://tryengineering.org/profile/materials-engineering/.

Miller, M. (2020, July 16). *Interactive Notebook Master Template*. Ditch That Textbook. https://ditchthattextbook.com/infographic/interactive-notebook-master-template/. Matt Miller @jmattmiller from DitchThatTextbook.com

NOVA. (2020, June 30). *Breaking Point: Testing Tensile Strength*. PBS LearningMedia. https://ca.pbslearningmedia.org/resource/nvms.sci.materials.strongerdemo/breaking-point-testing-tensile-strength/.

Nova. (2020, May 29). *Making Stuff Activity Guide*. PBS LearningMedia. https://thinktv.pbslearningmedia.org/resource/nvms-sci-msactguide/making-stuff-activity-guide/.

PBS LearningMedia. (2020, June 3). *Engineering For Good*. PBS LearningMedia. https://ca.pbslearningmedia.org/collection/engineering-for-good/.

Plastic. BrainPOP. https://www.brainpop.com/technology/scienceandindustry/plastic/.

Project Lead the Way. (2020, July 23). *Store Resources*. PLTW. https://www.pltw.org/mypltwresources.

Striepe, B. (2012, October 8). *Tutorial: Make Fabric from Upcycled Plastic Grocery Bags*. Organic Authority. https://www.organicauthority.com/live-grow/tutorial-make-fabric-upcycled-plastic-grocery-bags.

Upcycle Plastic Grocery Bags Into a Colorful Tote. HGTV. https://www.hgtv.com/design/make-and-celebrate/handmade/upcycle-plastic-grocery-bags-into-a-colorful-tote.

Wilkinson, K., & Petrich, M. (2017). Fuse Your Own Fabrics. In *The Art of Tinkering: Meet 150+ makers working at the intersection of art, science & technology* (pp. 185–189). essay, Weldon Owen.

Woodford, C. (2019, December 6). *How do adhesives and glues work?: The science of sticking*. Explain that Stuff. https://www.explainthatstuff.com/adhesives.html.

YouTube. (2019, January 22). *The Different Types of Adhesives - YouTube*. Quality Logo Products. https://www.youtube.com/watch?v=6qutTkJ4rO8.

Links for more teacher support:

Engineering Notebook

Ditch That Textbook. Matt Miller @jmattmiller DitchThatTextbook.com

Project Lead the Way publicly shared general resources
https://www.pltw.org/mypltwresources

Harvard Project Zero Agency by Design Thinking Routines
http://www.agencybydesign.org/explore-the-framework

Engineering Notebook
https://www.amazon.com/gp/product/1686840373/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1

Materials Research Society - Education Outreach
https://www.mrs.org/programs-outreach/education-and-public-outreach/additional-education-outreach-programs

Keywords / Vocabulary

Materials, Materials Engineering, Composite, Makerspace, Plastic Fusing, Material Tensile Testing

For student facing vocabulary, see Vocab DITLO Mat Eng GDoc.

Links to Teacher Created Files in this ETP

- Engineering Notebook Template in GSlides
- Unit outline
- Script for pre-recording interviews with volunteer mentor material engineers, based on LM PMP Lab Host Engagement
- Parts Purposes Complexities Grid template - Student
- Vocabulary DITLO Mat Engineering - Student
- Safety guidelines sheet - Student