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Mandatory 4: Final Paper  
Spring 2018

## **Engineering in the Classroom: A Lesson in Leadership**

### **Background**

This paper summarizes the professional development project that I created with the goal of helping my school's facilitators (teachers) feel more confident and comfortable implementing *and assessing* engineering projects in their classrooms, grades K-8. Participants in the 2-hour session included eleven of the fourteen TK-8 facilitators at iLEAD Encino Charter School in Los Angeles, CA.

### **Standards Addressed**

The professional development focused on the NGSS Engineering Design standards broken down by K-2, 3-5, and Middle School (MS) levels.

### **Summary of Project**

The project was broken down into four stages:

1. I conducted an extensive survey to determine the confidence and competency of science and non-science facilitators in delivering and assessing NGSS Engineering projects.
2. Delivering a Professional Development session with my administrator's approval to address the areas that were the greatest barriers to the facilitators.
3. Working with self-selected facilitators after the PD to integrate and assess engineering projects into their current or upcoming projects.
4. Following up after the implementation and assessment of the engineering projects to evaluate student outcomes.

An important aspect to this project this semester was an abrupt shift in our organization's focus in late February which adversely affected facilitator commitment, shifting from integrated content project

planning to Math and Reading specific curriculum structures, in order to ensure approval of our charter for the upcoming year. Science and Engineering took a back seat. Nevertheless, two facilitators were eager to continue to work with me in some capacity.

### **Pre-questions Survey**

15 of 18 staff members contributed to the pre-PD survey. In addition to TK-8 facilitators were the Robotics coach, Mandarin facilitator, PE coach, and four Care Team (student support) members. One of these Care Team members is the primary facilitator for the Makerspace, which involves all “shop” and engineering activities.

What participants wanted to learn in the PD:

How to assess engineering components in any project

4

How to use resources and conduct engineering workshops

2

How/why to include “make” components in non-science projects

9

Of all participants, 10 felt neutral to confident in the Engineering Design process; 7 of the 10 were neutral (the Robotics Instructor was the only “highly confident” response). Of the participating facilitators with a science focus, 2/3 felt uncomfortable with the NGSS Scientific & Engineering Practices and 2/3 felt uncomfortable with the Engineering Design standards. All facilitators felt that the process of the project was the most important element in an engineering project (how we get from A to B, teamwork, rigor), and that learners should be able to present their projects in a way that is personal or meaningful to them (in other words, no two projects will be the same, and having all learners do the same activity with the same/similar outcome is undesirable).

### **Professional Development Training**

Based on the results of the survey, I developed a PD with a focus on “how/why to include engineering in non-science projects” in order to shift the mindset from a “fear” of engineering to one of understanding in terms of current practices.

I first defined what Engineering and the Engineering design process are, and how they contribute to everything in the world that we use. We did an activity in which facilitators thought of a project their learners were doing or will soon be doing that was hands-on, and whether it solved a problem, sorting these on a Venn Diagram on the board for Engineering vs. Art, and the vast majority of post-its were in the middle. Then we looked at problems that people solved in history, language barriers, and music, with many examples of how some typical in-class art or craft projects can actually be modified and evaluated as engineering projects. We then did an activity in which facilitators looked at some of these project examples against a broken-down, score-able version of the NGSS Engineering standards to see how we could evaluate them (see appendix 3).

### **Activities in the Pick-up Unit**

I did not conduct the pick-up unit in the PD because there would not really be one that applied to all grade levels and ongoing projects, that was not also specifically science-oriented. Instead I worked one-on-one as a consultant to facilitators who wanted to incorporate

### **NASA Data**

NASA resources and data were not used in this project, except as resources provided to the facilitators to encourage them to use them in upcoming projects.

### **Follow-up Activities & Survey**

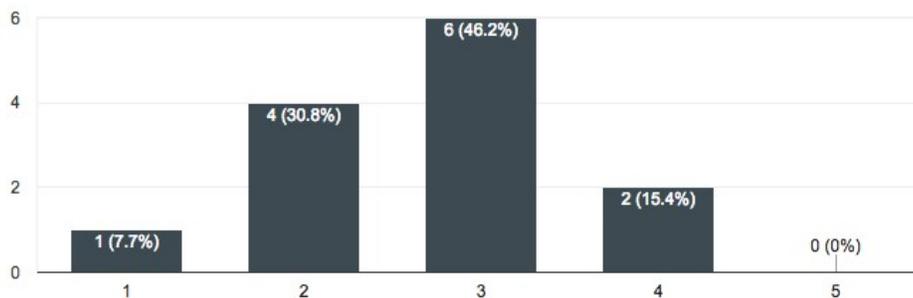
The fact that several facilitators wanted to use engineering standards to evaluate components of projects that have previously been un-graded, and that several facilitators wanted to make sure they were correctly including an engineering component into their upcoming projects, tells me that the overall PD was a success, and has helped me to see what next steps I will have to take to work with my fellow facilitators to help them implement with consistency in their projects going forward.

13 of the PD participants completed the follow-up survey. These were not necessarily the same 15 who completed the pre-survey. Prior to PD, only 4 felt confident about their knowledge of Engineering, with 6

neutral, but afterward, 12 felt confident, with one neutral. Likelihood to implement “make” components in a project increased from 8 to 10, but one shifted from not at all to somewhat likely, and the majority shifted positively. 92% felt the hand-outs about NGSS standards were helpful. 61% felt the resources hand-out would be helpful.

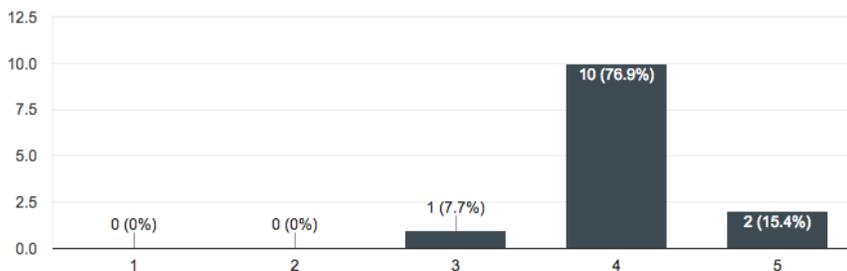
Indicate your level of knowledge of Engineering prior to the PD.

13 responses



Indicate your level of knowledge of Engineering after to the PD.

13 responses



## **Outcomes**

I have consulted on several projects with both science facilitators and one history facilitator. One project is still ongoing until June 6 so it will be impossible to determine student outcomes prior to then. Two others were completed recently. Neither used available NASA resources (as the majority of projects outside my own classroom are “creatively” designed, and not always relevant to a NASA-related theme or concept). I would love to have worked more with lower-school facilitators but grades TK-3 are on another campus.

Ethan Norof, 6<sup>th</sup> grade science teacher, worked with me to revise his rubric for the game design project his learners were working on. We

shifted some of the assessments he had been considering to more objective engineering standards, as well as incorporated some of the Science & Engineering Practices. He felt this process helped make the project requirements more clear, and helped to provide the learners with tools to self-evaluate and to also critique and compare one another's work objectively. Norof feels this will work even better in his next project, which has a strong engineering component.

Jackson Thompson, 5<sup>th</sup> grade math and science teacher, asked me to help design an engineering component for their cross-curriculum "election" project. The science concepts he was hoping to address were electricity and circuits, but this did not seem relevant to the social-studies emphasis of elections and democracy. We discussed using simple circuits in campaign promotions, and we used the engineering standards for grades 3-5 to help define how this would be assessed. He had done a similar activity the year before, but with a different project, and it did not have good results. When this year's was implemented, learners came up with etextile solutions with blinking lights in hats, making "interactive" (buzzers) or light-up posters, and other creative uses for circuits that neither he nor I had imagined.

Paola Santiago, the TK/K/1 teacher,

Corina Powell, 7<sup>th</sup> and 8<sup>th</sup> grade history facilitator, wanted her 8<sup>th</sup> graders to join another school's Civil War reenactment, which requires a lot of engineering solutions. She was not present at the PD, but I shared with her the engineering standards by which we could evaluate the 8<sup>th</sup> graders' construction of costumes and props. (This is the one coming out June 6.)

I collaborated with the 7<sup>th</sup> and 8<sup>th</sup> grade math teacher, Michelle Guire, to make a "practical application of math" in preparation for testing, in which we decided to do a 2-week engineering challenge of measurements, conversion, and proportions/scale. I am not sure how much this contributed but almost all math scores went up for 7<sup>th</sup> and 8<sup>th</sup> graders.

## **Relation to Readings**

The overall project related to the readings in several ways. First, reading the DeSimone (2011) article helped clarify that PD does not simply happen in a conference room; that it happens everywhere, but that some methods are more effective, and it depends on what the desired outcomes are. For example, in this case, the awareness component of the PD was provided in a classroom setting, but the most effective component happened with the consultations after the PD.

Second, the Daugherty (2009) article came after my PD, but it helped to reinforce that my PD is merely a baby step; that good engineering training is not going to happen in one short PD; and that I may need significantly more PD myself before I am able to transfer knowledge in the most effective or efficient manner to my fellow facilitators. The curricula discussed in the article was highly involved and intensive, and my two-hour awareness training could be used to inspire other facilitators to deep-dive into more intensive training themselves.

### **Reflection / Conclusion**

Overall, based on post-PD activities, the PD helped to accomplish the following:

- Increased understanding of what engineering is, and how it applies in all content areas (not just an abstract or advanced scientific concept for experts)
- Increased facilitator interest in implementing engineering components
- Increased confidence in implementation with those who sought my help
- Increased student engagement in content
- Helped facilitators assess activities objectively in ways that were either challenging to assess prior, or not assessed at all

We hope to have all of K-8 on one campus next year; if not, we will have K-5 on one campus and 6-12 on another. A second campus may be added to our organization, which means even more facilitators who can benefit from this, and additional, PDs in engineering. I am grateful to have had this practice so that I can improve the PD and reach twice as many facilitators.

All our PDs will be together as one, and I will be requesting six hours of PD time for a 3-part, expanded version of this PD so that I do not need to work one-on-one, but empower the co-teaching teams to work together to ensure that engineering practices are an integral part of their project planning, and that they have the confidence and tools to implement and assess engineering effectively.

## **References**

Daugherty, J. L. (2009). *Engineering professional development design for secondary school teachers: a multiple case study*.

Desimone, L. M. (2011). *A primer on effective professional development*. Phi Delta Kappan, 92(6), 68.

## **Appendix 1: Classroom Activities/Unit with Assessment**

I did not implement a science or engineering “sample” activity in my PD. Instead I introduced several resources to help my facilitators recognize that engineering is broadly applicable to many projects. I had hoped to have a follow-up PD in which we did a hands-on “personalized” activity in the Makery, so that each facilitator could apply the activity to a project they are currently working on (or recently completed) from the point of view of both the student and the evaluator.

## **Appendix 2: Professional Development Attendees**

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## **Appendix 3: NGSS Engineering Design Standards/Rubric Sample (Hand-Out)**

## **Appendix 4: Engineering Resources (Hand-Out)**

# ENGINEERING DESIGN STANDARDS / RUBRIC SAMPLE

## K-2

Did the learner...

<b>Define the problem</b> Points ____ / 3	Ask a question about the people or problem?	Re-state the problem or what needs to change or be created?	Point to or verbalize observations or facts about the problem?
<b>Make a sketch</b> Points ____ / 2	Draw a sketch or representation of the problem?	Use shapes to show the problem OR or a possible solution?	Indicate how the shape(s) fits the solution or function of the solution?
<b>“Analyze data”</b> Points ____ / 3	Choose 2 objects or possible solutions to compare?	Test both objects in a fair / equal way?	Write, draw, or verbalize results?

## 3-5

Did the learner...

<b>Define the problem</b> Points ____ / 3	Define a specific, simple problem reflecting a need or want?	Identify criteria for success?	Identify potential problems and/or constraints
<b>Compare solutions</b> Points ____ / 3	Brainstorm at least two possible solutions?	Compare/contrast the solutions against each other?	Predict possible problems based on criteria and constraints.

<b>Carry out fair tests</b>  Points ____ / 3	Identify one variable at a time to test?	Record data and/or observations from multiple, relatively equal trials?	Write or draw suggested improvements based on tests?
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# Middle School

Did the learner...

<p><b>Define a problem</b></p> <p>Points ____ / 5</p>	<p>Identify and state a specific and relevant problem to solve?</p>	<p>Use research and prior learning to support the problem statement?</p>	<p>Identify and state constraints, challenges, and potential problems?</p>	<p>Describe the desired outcome and potential impact, good and/or bad?</p>	<p>Revise and restate their question based on new or updated information?</p>
<p><b>Evaluate designs</b></p> <p>Points ____ / 5</p>	<p>Identify two or more competing design solutions for a single problem?</p>	<p>Determine a systematic process to compare and contrast the competing designs?</p>	<p>Use the systematic process to evaluate the designs against criteria for success?</p>	<p>Use the systematic process to evaluate the designs against constraints of the problem?</p>	<p>Communicate the results of the evaluations as a conclusion based on the evidence?</p>
<p><b>Analyze data</b></p> <p>Points ____ / 5</p>	<p>Conduct tests on one or more models or prototypes?</p>	<p>Record data and observations from the tests?</p>	<p>Analyze to identify the most effective characteristics of each model?</p>	<p>Analyze to identify the flaws and least effective characteristics in each model?</p>	<p>Revise at least one model based on the results of the analyses?</p>
<p><b>Develop a model</b></p> <p>Points ____ / 5</p>	<p>Brainstorm multiple ideas or approaches to solve the stated problem?</p>	<p>Construct a working or functional model of one of the ideas?</p>	<p>Test the model multiple times, revising after each test?</p>	<p>Record and use test data to identify flaws and improve performance?</p>	<p>Justify the final iteration of the design as optimal based on tests?</p>

Problems can be scientific, historical, social, or any other need in which a solution can be derived (such as picking up trash).

Models can be 2D or 3D, live-action, data-driven, computerized, blueprints, schematics, simulations, etc. Ideally it shows a system or flow.

Models can be of objects, tools, or processes, of natural phenomena or historical events, of solutions to social or world problems, etc.

An engineering project does not need to include all four performance areas. Adapt within the performance areas as needed.

# ENGINEERING RESOURCES

PBSKids.org Design Squad (Grades 2-8)

<http://pbskids.org/designsquad/parentseducators/workshop/welcome.html>

Engineering for Kids

<http://engineeringforkids.com/>

Curiosity Machine (5-8, PBL)

<https://www.curiositymachine.org/challenges/>

Teach Engineering

<https://www.teachengineering.org/>

eGFI: Engineering Go For It! (K-12, PBL)

[http://www.egfi-k12.org/index\\_noflash.php](http://www.egfi-k12.org/index_noflash.php)

## NASA RESOURCES

Nasa Educator Resources (General)

<https://www.nasa.gov/audience/foreducators/index.html>

Grades K-4

<https://www.nasa.gov/audience/foreducators/k-4/index.html>

Grades 5-8

<https://www.nasa.gov/audience/foreducators/5-8/index.html>

Grades 9-12

<https://www.nasa.gov/audience/foreducators/9-12/index.html>

NASA/JPL Education Activities

<https://www.jpl.nasa.gov/edu/teach/>

## ELECTRONICS

Because Learning (formerly ArduSat)

<https://www.becauselearning.com/>

Squishy Circuits

<https://squishycircuits.com/>

## ROBOTICS & CODING

Robot Virtual Worlds

<http://www.robotvirtualworlds.com/>

MIT App Inventor 2

<http://ai2.appinventor.mit.edu/>

Scratch Coding

<https://scratch.mit.edu/>

Tynker

<https://www.tynker.com/>

Code.org

<https://code.org/>

## VIDEOS TO INTRODUCE ENGINEERING

What is Engineering?

<https://youtu.be/bipTWWHya8A>

What's an Engineer? Crash Course Kids #12.1

<https://youtu.be/owHF9iLyxic>

Be an Engineer! Sci Show Kids

<https://youtu.be/D9I35Rqo04E>

The Engineering Process: Crash Course Kids #12.2

<https://youtu.be/fxJWin195kU>

NASA for Kids: Intro to Engineering

[https://youtu.be/wE-z\\_Tjyzil](https://youtu.be/wE-z_Tjyzil)

PBSKids.org Design Squad - What's Great About Engineering (series)

<http://pbskids.org/designsquad/parentseducators/workshop/engineering.html>