Make Way for 3-D printing

Subject Area(s) Chemistry, Measurement, Physical Science, Science and Technology

Activity Title(s) What is an Engineer, Engineering Careers, Why is this Important, Let's Print Day 1, Let's Print Day 2

Grade Level 4

Time Required 45-60 minutes per activity

Number of Students: Groups of 2-3

Expendable Cost per Group US $4 for the entire unit

Summary

This unit is designed to give students an understanding of one aspect of what an engineer does and the ability to experience various steps in the engineering design process. The activities in this unit will use concepts such as; measurement, lab safety, following a prescribed method, and working in teams. Students will begin by researching what an engineer is and various engineering jobs, and then present the information they found to their peers. Then we will be watching a video and taking notes on the engineering design process. In the real world engineers use this process to determine how effectively a material, such as a drug for cancer treatment, can reach its target. They will learn to how to complete an investigation using lab safety rules and notating observations, just like an engineer. Students will work in teams to carry out investigations in 3-D printing by using a blunt tip needle syringe to print a variety of colored liquid materials into a small plastic box filled with a gel base. The teams will observe the interactions between the printed material and the gel base at intervals of 30 minutes and 1 hour and then notate their observations in our lab notebooks. This step will be repeated with multiple materials and will take place over a couple of days. Teams will share their results to compare with their classmates. The final day's investigation will be completed by the teams independently. A rubric will be used on this day for a final assessment in determining the students ability to carry out the investigation independently.

Engineering Connection

The investigation is simulated after a real-world engineering design in which researchers investigated 3-D printing cells in a gel base, and then introducing a dye into the base to determine the ability of the dye to diffuse through the base and make it to the cells. (Bhattacharjee, et al. 2016) The students will be using several steps in the engineering design process such as; defining a problem, performing background research, testing the design solution, and sharing their results. (Science Buddies)

Engineering Category Category 2- Engineering analysis or partial design process

Keywords

approximate, iteration, 3-D printing, syringe, research, engineering, engineering design process

Educational Standards

State STEM Standards

SC.35.CS-CS.1.2 Describe how models and simulations can be used to solve real-world issues in science and engineering.

SC.35.CS-CS.2.4 Solve real-world problems in science and engineering using computational thinking skills.

ITEEA Standards

The Nature of Technology 1.D Tools, materials, and skills are used to make things and carry out tasks.

Technology and Society 6.B Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.

Design 8.C The design process is a purposeful method of planning practical solutions to problems.

Design 9.C The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.

Design 9.E Models are used to communicate and test design ideas and processes.

Abilities for a Technological World 11.F Test and evaluate the solutions for the design problem.

Abilities for a Technological World 12.E Select and safely use tools, products, and systems for specific tasks.

Abilities for a Technological World 12.F Use computers to access and organize information.

Abilities for a Technological World 12.G Use common symbols, such as numbers and words, to communicate key ideas.

Abilities for a Technological World 13.C Compare, contrast, and classify collected information in order to identify patterns.

Abilities for a Technological World 13.D Investigate and assess the influence of a specific technology on the individual, family, community, and environment.

The Designed World 14.D Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.

The Designed World 17.D The processing of information through the use of technology can be used to help humans make decisions and solve problems.

NGSS Standards

4-ESS3-1 Knowledge of relevant scientific concepts and research findings is important in engineering.

4-ESS1-1,4ESS2-2 Patterns can be used as evidence to support an explanation.

CCSS Standards

MAFS.K12.MP.5.1 Use appropriate tools strategically.

Pre-Requisite Knowledge Students should have foundational knowledge of science tools, various measurement tools, science lab safety, and basic research knowledge.

Vocabulary / Definitions

Word	Definition
Engineering	Engineering is the practice of using scientific and mathematics principles and practices to design solutions for real world problems. Study.com
Approximation	The act of doing something similar, but not exactly the same as an engineer
Iteration	A necessary change made to a design while in the engineering design process to
3-D Printing	The use of a printer to creating a multidimensional, tangible object Dictionary.com
Lab Notebook	A notebook for documenting and recording investigation processes and results

Lesson Background & Concepts for Teachers

Teachers will need to have an understanding of what an engineer is (see vocabulary chart above) and the steps of the engineering design process. The steps of the engineering design process are: "define the problem; do background research; specify requirements; brainstorm, evaluate, and choose a solution; develop and prototype a solution; test the solution; and communicate results." (Science Buddies) The teacher will also need to have an understanding of what 3-D printing is. In 3-D printing, generally, the machine used to print will have a print head that can move around, like a traditional printer. A 3-D printer, however, can move from side to side and up and down. So a 3-D printer has much more capability with regards to how it moves around in space to manufacture a completed product. The 'ink' used for printing can vary widely depending on the project. It can be a plastic, cells, or like we are using in this lesson, a liquid-like substance.

Day 1

Learning Objectives

After this activity, students should be able to:

- explain what an engineer does and why engineering is important.

Materials List

Each group needs:

- index cards for taking notes
- computer and internet access

Procedure

1. Before the Activity-Gather a list of appropriate websites for students to use for research. Good search engines to use are *kiddle.com,* *www.sciencekids.co.nz*

2. With the Students- Review research procedures and internet safety with the students using the Touch Down/Take Off Kagan strategy. Students will "take off" or stand up if they agree with the statement being made. Students will "touch down" remain sitting if they do not agree with the statement. After the students have made their choice they all touch back down to start again. *Sample Questions: True or False-When using the computer you should follow your teacher's instructions, Today we will be researching banannas, It is not okay to have background programs(games) running while you are doing your research. It is important to share what we have learned with others.*
Team up students in pairs of 2-3, give the teams index cards for notes, and allow students 15-20 minutes to work together to complete their research. At the end of the time period, allow each team to present what they have learned with the class.

Assessment

Post-Activity Assessment- Teacher will use the same "Touch Down/Take Off" strategy to answer questions about what they learned and what others presented. *Questions you use will vary depending on what findings your students share with each other. Good questions to ask would be what is an engineer, how do they help us, etc…*

Day 2

Learning Objectives

After this activity, students should be able to:

● Share specific details with the class about the engineering career they chose to research

Materials List

Each group needs:

● index cards for taking notes
● computer and internet access
● sheet of paper to use for pre-assessment activity
●bucket

Procedure

1. Before the Activity- Gather list of appropriate websites for students to use for research. Good search engines to use are *kiddle.com, www.sciencekids.co.nz*. Write various engineering careers on an index card, fold, and place in the bucket. Possible career choices are: Aerospace Engineer, Agricultural Engineer, Biomedical Engineer, Chemical Engineer, Civil Engineer, Architectural Engineer, Flight Engineer, Computer Hardware Engineer, Electrical Engineer, Environmental Engineer, Industrial Engineer. Health and Safety Engineer, Marine Engineer, Mechanical Engineer, Nuclear Engineer.

2. With the Students- Review research procedures and internet safety with the students. Have students fold a sheet of paper in half and write "yes" on one side and "no" on the other. Review yesterday's research on what an engineer is/does. Students will use their "yes"/"no" cards to either agree or disagree with a statement made. Good questions to ask would be; *An engineer solves problems(yes), An engineer doesn't share their findings with others (no), Engineers test their solutions to a problem(yes).* Have students work with the same group as they worked with on day 1. Each group draws a card from the bucket, this will give them the engineering career they will be researching. Each team gets index cards to take notes on, and then after about 15-20 minutes they will present their findings to the class.

Assessment
Pre-Activity Assessment- "Yes"/"No" cards to review Day 1 discussion on what an engineer is and the possible job opportunities are.
Post-Activity Assessment- Notes taken on index cards during team research

Day 3

Learning Objectives
After this activity, students should be able to:
● Identify the steps in the engineering design process and specific examples of engineering research that we all benefit from in our everyday lives.

Materials List
Each student needs:
●A copy of the video notes to complete.

Procedure
1. Before the Activity-Preview the video titled "Engineering Compilation: Crash Course Kids" https://www.youtube.com/watch?v=qDcMq1SjR_I&t=1124s. Print out a class set of the video notes.

2. With the Students- Go over classroom expectations regarding watching a video. Preview the video notes worksheet with them so they know what to listen for during the video. They should be filling out their notes during the video. Watch the video with the students. After the video review the notes and answers with the students.

Assessment
Post-Activity Assessment-Completed Video Notes

Troubleshooting Tips- The video narration may be too fast for your students. You may need to slow down the video speed.

Day 4
Learning Objectives
After this activity, students should be able to:
● Fill a clear box with a gel, use a blunt-tip needle syringe to remove the air bubbles from the material
●With guidance from the teacher, 3-D print a line of colored liquid-like substance within a gel material
●Use a timer to measure out intervals for making observations, take down data

Materials List
Each group needs:

● plastic box for printing in
● small spatula
● gloves
● safety goggles
● syringe
● Hair gel-base for "printing in"
● paint
● food coloring for dye
●shampoo
●conditioner
●aloe
● hand sanitizer
● timer
●small disposable container for "waste"
●napkins
●recording sheet-one per student

Procedure

1. Before the Activity- Using food coloring pre-dye the shampoo, conditioner, aloe, and hand sanitizer. These as well as the paint will be the "ink" for printing. Set up materials for each group which should include; several pairs of gloves, safety goggles, one box for printing in, syringe, waste container, and give each group a pre-dyed ink. Teacher should have a set as well.

2. With the Students-

a. Divide students into groups of 2-3

b. Review lab safety protocols; using gloves and goggles, keeping materials off our skin and out of mouths, using materials responsibly (such as the syringe)

c. Discuss how to be an effective lab partner; team members will share the tasks equally, each team member is responsible for recording data on their recording sheets, etc… you can include more, if you want.

d. The teacher will model each step during this activity and allow each team to replicate the step immediately after the demonstration of each step. Teacher and students will:

Step 1: Squeeze the hair gel in the clear box, filling it up and smoothing over the top. Use the syringe to suck out the air bubbles. Allow each group the time to complete this task. Empty any residual gel from the syringe into the disposable "waste" container. This is an approximation of what engineers do, when working with chemicals they must always dispose of them properly.

Step 2: Fill the syringe with one of the pre-dyed inks. Allow each group the time to complete this task.

Step 3: Insert the needle into the gel, about an inch deep. "Print" a line of the ink within the gel. This means you will push down the plunger of the syringe continuously while dragging it slowly through the gel base in the clear container. The width in diameter of the line should be about the width and length of a toothpick. Allow each group time to complete the task.

Step 4: Set the timer for 30 minutes. When time is up observe whether the color has diffused through the gel base and document any observations.

Step 5: Set the timers for another 30 minutes and when the time is up observe the lines again and take observations on whether the color has diffused through the gel base. Allow each group to share their observations.

Assessment

Activity Embedded Assessment- Anecdotal observations; as teams are completing the investigation are the students working together to complete the task? Are they correctly completing the tasks? Are they being safe while completing the tasks? Are they recording their data?

Troubleshooting Tips- If the students are having difficulty loading the syringe with the ink, you can remove the needle tip by twisting it off, then sucking up the ink without it and twisting it back on.

Safety Issues-The needle tip is blunt, not sharp, it should not injure the students if they are using their supplies safely. I did monitor my students closely as they were using it and I made sure that all syringes were collected and counted at the end of the investigation.

Day 5

Learning Objectives

After this activity, students should be able to:

● Replicate the steps from Day 4 investigation with little guidance from the teacher

● Fill a clear box with a gel, use a blunt-tip needle syringe to remove the air bubbles from the material

●3-D print a line of colored liquid-like substance within a gel material

●Use a timer to measure out intervals for making observations, take down data

Materials List

Each group needs:

● plastic box for printing in

● small spatula

● gloves

● safety goggles
● syringe
● Hair gel-base for "printing in"
● paint
● food coloring for dye
●shampoo
●conditioner
●aloe
● hand sanitizer
● timer
●small disposable container for "waste"
●napkins
●recording sheet-one per student

Procedure

1. Before the Activity- Using food coloring pre-dye the shampoo, conditioner, aloe, and hand sanitizer. These as well as the paint will be the "ink" for printing. Set up materials for each group which should include; several pairs of gloves, safety goggles, one box for printing in, syringe, waste container, and give each group a pre-dyed ink. Teacher should have a set as well.

2. With the Students-

a. Divide students into groups of 2-3, using the same teams as day 4

b. Review lab safety protocols; using gloves and goggles, keeping materials off our skin and out of mouths, using materials responsibly (such as the syringe) and what is means to be an effective lab partner.

c. Before students begin, the teacher will complete the investigation to review the steps with the students. Before the teacher completes each step, the students must tell the teacher what needs to be done.

d. Give students the investigation rubric and data recording sheet and go over expectations for successful completion of the investigation.

e. Allow each group time to complete steps 1-5, using the same ink they used on day 4 to compare the results from both days

Assessment

Pre-Activity Assessment-Are the students able to give the teacher the correct directions and steps in the correct order to complete the investigation.

Post-Activity Assessment- Are teams able to create a final product and effectively 3-D print a sample for observation. A rubric will be used to assess each students' performance during this task.

Troubleshooting Tips- If the students are having difficulty loading the syringe with the ink, you can take off the needle tip by twisting it off, then sucking up the ink without it and twisting it back on.

Safety Issues-The needle tip is blunt, not sharp, it should not the students if they are using their supplies safely. I did monitor my students closely as they were using it and I made sure that all syringes were collected and counted at the end of the investigation.

Contributors
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Supporting Program
Multidisciplinary Research Experiences for Teachers of Elementary Grades (PI: Prof. Chelsey Simmons), Herbert Wertheim College of Engineering, University of Florida

Acknowledgements
This curriculum was developed under the National Science Foundation EEC grant no. 1711543. However, these contents do not necessarily represent the policies of the NSF, and you should not assume endorsements by the federal government.

Classroom Testing Information: The rubric used on Day 5 is the final assessment for this activity.

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Engineering Video Notes

Taken from *Engineering Compilation: Crash Course Kids*

https://www.youtube.com/watch?v=qDcMq1SjR_I&t=34s

1.) An engineer is someone who wants to know _____ and _____ things work.

2.) An engineer is someone who _____ and _____ things to solve a _____.

3.) What are the three questions they ask themselves while working?

a. What is the problem that needs to be _____?

b. _____ has the problem that needs to be solved?

c. _____ is this problem important to solve?

4.) What problem was the invention of the microwave a solution to?

5.) Who is a famous engineer around today?

6.) What is the series of steps that all engineers follow called?

7.) What are the steps of the Engineering process?

a. _____ the problem.

b. Do your _____.

c. _____ a possible solution.

d. Design your _____.

e. Build a _____.

f. _____ it.

g. _____ your solution.

8.) Why was dynamite invented?

9.) A prototype is a _____ _____ that lets you test out your design.

10.) What are some solutions that engineers have come up with?

11.) Engineers identify_____ when they are looking at and testing _____ to a _____.

12.) An _____ is the way something turns out or the _____.

13.) There is more than one _____ to a problem.

14.) A _____ point is where a solution to a _____ has a limit.

15.) Engineering is about solving _____.

Engineering Video Notes

Taken from *Engineering Compilation: Crash Course Kids*

https://www.youtube.com/watch?v=qDcMq1SjR_I&t=34s

1.) An engineer is someone who wants to know **how** and **why** things work.

2.) An engineer is someone who **designs** and **builds** things to solve a **problem**.

3.) What are the three questions they ask themselves while working?

a. What is the problem that needs to be **solved**?
b. **Who** has the problem that needs to be solved?
c. **Why** is this problem important to solve?

4.) What problem was the invention of the microwave a solution to?
Cold food

5.) Who is a famous engineer around today? **Marissa Mayer**

6.) What is the series of steps that all engineers follow called?
Engineering Process

7.) What are the steps of the Engineering process?

a. **Define** the problem.
b. Do your **research**.
c. **Develop** a possible solution.
d. Design your **solution.**
e. Build a **prototype.**
f. **Test** it.
g. **Evaluate** your solution.

8.) Why was dynamite invented?

To make it safer for the miners to do their jobs.

9.) A prototype is a **simple** **model** that lets you test out your design.

10.) What are some solutions that engineers have come up with?

Answers vary: microwave, software, Golden Gate Bridge, telephone,

11.) Engineers identify **variables** when they are looking at and testing **solutions** to a **problem** .

12.) An **outcome** is the way something turns out or the **solution**.

13.) There is more than one **solution** to a problem.

14.) A **failure** point is where a solution to a **problem** has a limit.

15.) Engineering is about solving **problems**.

Make Way for 3-D Printing

Day 1

Step 1:

Step 2:

Step 3:

Step 4:

Step 5:

Observation 1(after 30 minutes)

Observation 2 (after 1 hour)

Make Way for 3-D Printing

Day 2

Step 1:

Step 2:

Step 3:

Step 4:

Step 5:

Observation 1(after 30 minutes)

Observation 2 (after 1 hour)

Make Way for 3-D Printing

Name:

	4. Distinguished	3. Proficient	2. Apprentice	1. Novice
Behavior-Respect: Showed proper care for others, things, and self	Made many nice comments about other people and their work. Took extra care using materials. Was careful when looking at other students work.	Made nice comments about other people and their work. Followed rules about using materials. Took care of their own work.	Sometimes made comments that were not appropriate. Damaged materials used, own work, or work of others.	Said mean things about other people and their work. Broke materials. Did not take care of own work.
Lab Work-Observations: Record data about what happened	Wrote down all data in clear handwriting. Made a chart to show the data. Had many details about what happened during the experiment.	Wrote down all data in clear handwriting. Had details about what happened during the experiment.	Missed up to three pieces of data. Wrote down most of the steps in the experiment.	Missed more than three pieces of data. Wrote down some of the steps in the experiment.
Lab Work-Safety: Follows rules and uses good judgment	Followed all safety rules and wrote about safety in their lab report.	Followed all safety rules.	Did not follow all safety rules.	Did not follow safety rules and caused a dangerous situation.
Behavior-Follows Instructions: Listens to instructions and follows directions	Paid close attention to instructions, and asked questions when needed. Followed all directions in the order they were given.	Listened closely to instructions, and followed directions without a lot of teacher help.	Listened to instructions, but did not complete all directions.	Did not listen to instructions, and only followed directions when prompted by teacher.

Make Way for 3-D Printing

Name:

____ I properly cared for others, things I used, and myself.

____ My lab report has data that shows what happened during the experiment.

____ I followed safety rules.

____ I listened to instructions and followed directions.