**Engineering Your Own Liquid Soap: Lesson Sequence, Suggested Teacher and Students' Actions, and Corresponding Assessments.**

[The name of specific pedagogical strategies used are shown in brackets].

| **Estimated Time** | **Teacher's Actions [Pedagogical Strategy]** | **Students' Actions** | **Assessment** |
|---|---|---|---|
| 5 min | [Creating a need to know-Demonstration]<br>GloGerm demonstration | Student volunteer for demonstration | Watch for students' prior knowledge and misunderstandings about germs/viruses. This will be addressed below. |
| 7 min | [Teacher-led, whole class discussion]<br>Why is it important that we do more than just washing our hands?<br>Who knows the proper hand-washing technique?<br>[Short video-based discussion]<br>See hand-washing video listed on resources | Students share ideas<br><br>A different student volunteer demonstrates his/her own hand-washing technique<br><br>A different volunteer imitates the proper hand-washing technique for the class | Depending on students' age and knowledge, each student should practice using the hand-washing technique until it has been mastered before proceeding.<br>**Tip**: *To move this process along, invite volunteers, assistants, and principal to help evaluate the students. Students often forget to wash their nails.* |
| 5 min | [Brainstorm concept map/whole class]<br>What do we know about germs? About viruses like the COVID-19?<br>**Tip:** *Avoid being the "sage on the stage" and focus on assessing students' prior knowledge. Students will gain the science content knowledge they need later in the lesson.* | Students freely contribute ideas | Save concept map and use later for students to correct misunderstandings and add new knowledge |

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| | *****It is important to open a discussion about health inequalities in the US and encourage students to think about what they would do differently<br>*Also, stress the role (agency) students have in helping keep their families safe by properly washing their hands and wearing masks. | | Check for students' emotional state. Some students may have been directly affected by COVID-19.<br>Allow them to share if they are comfortable. |
| **Estimated Time** | **Teacher's Actions [Pedagogical Strategy]** | **Students' Actions** | **Assessment** |
| 5 min | [Problem-solving: share design task]<br>Use Fig 1 to remind students of Eng Design Process.<br>I. Identify Tasks (Fig 1): showcase ingredients (Figure 2) | Students freely ask clarifying questions | |
| 5 min | II. Form collaborative groups (Fig 1)**:** Ensure that diversity is well-represented in groups and address special needs | | |
| | **Tip**: *If time is a constraint, stop lesson here and continue next day; otherwise, take advantage of students' curiosity now* | Students discuss activity with parents/guardians at home & invite them to participate. | |
| 15-30 min | [Learning Stations]<br>III. Investigate (Fig 1):<br>In their teams (3-4 students), students rotate through learning stations to gain knowledge<br>**TIP**: *We use one iPad/team with all the information and links set up in advance. If technology is limited, either show videos whole-* | | Each Brainpop video has a short |

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| | *class, or have teams rotate to your x number of computers/tablets while having the rest of the class work on a different subject*.<br><u>BrainPop stations</u> (links listed on resources section)<br>*Corona virus<br>*How soap works<br>*Flu and flu vaccine<br>**TIP:** *The next stations are meant for older children (grades 5+) and require higher reading skills. These can be adapted for younger children by doing a slide show with photos and key information.*<br><br><u>Scientists & Engineers</u> (links listed on resources section)<br>*11 Black Chemists and Chemical Engineers. *Thought Co*.<br>* What Do Chemical Engineers Do?<br><br><u>Contributions of others to science knowledge</u> (links listed on resources section)<br>*Copal, the Blood of Trees<br>**TIP:** *The STEM Teaching Tools explain well why teachers should make diversity and equity more visible in the classroom* | Each team views a different video and writes down any additional questions.<br><br>Students must fully complete a station before rotating to another.<br><br>Teams pick a chemical scientist or engineer they wish to learn more about and write a one-page bio with photos.<br>Assist in making a board display for the class<br><br>Students list and share ways in which essential oils, incense, and/or other aromatic herbs might be used in their communities | quiz to check for understanding. Students should complete quiz collaboratively; i.e. avoid competition. Record each team's score on quiz & focus on reviewing key concepts<br>**TIP:** *Encourage metacognition by having students ask each other about their rationale for their answers.* |
| | **TIP**: *This is a good place to stop if time is a constraint* | Students discuss activity with parents/guardians at home & invite them to participate. | |
| 10 min | <u>IV. Design Model (Fig 1):</u><br>***TIP**: To increase participation while* | Teams complete Table 1 making sure to write a | Table 1 must be completed and math calculations |

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| | *enforcing physical distance, cut coffee filter paper in small strips, write a number representing each of your essential oils. Put strips in a ziplock bag, add 3-4 drops of essential oil, and close. Do this for each of your essential oils. Each student can then be given a strip to smell and decide which essential oil they wish to use for their model. The strips can be then discarded without sharing to increase safety. It also reduces the handling of the essential oil bottles.*<br>*Remind students not touch the essential oils, and not to taste them or bring close to their mouth* | rationale how they are addressing the 4 constraints<br><br>For safety, only one student is allowed to handle the materials while other students provide guidance | accurate before proceeding |
| **Estimated Time** | **Teacher's Actions [Pedagogical Strategy]** | **Students' Actions** | **Assessment** |
| 15 min | [Building models]<br><u>V. Test Model (Fig 1):</u><br>Ensure that student handling materials wear gloves and goggles.<br>Table 2 is used to estimate soap efficiency<br>Table 3 is used to measure the other 3 constraints | Members of each team help complete Tables 2 and 3.<br>Members take turns washing hands with their soap using proper technique.<br>All members estimate and discuss efficiency of soap after 3 trials<br>All members use rubric (Table 3) to evaluate moisturizing, fragrance and total cost aspects | Tables 2 and 3 must be completed including summary of findings statement before |
| 20 min | VI. <u>Seek Community Feedback/Re-test ( Fig.1):</u><br>Facilitate sharing of teams' results using multimedia (e.g., students take photos of using iPad or phones; | Team members take equal turns sharing findings<br>**TIP:** *Encourage development of argumentation skills by requiring students to use* | Revised summary of findings (Table 3) and Parts b and c of Table 3 must be |

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| | project results using a document projector or computer).<br><br>Facilitate collaborative, non-competitive community and encourage students to help each other by providing constructive criticism. | *sentences frames, such as: "We found X; "Our results show that;" "Based on our findings, we conclude that"*<br><br>After each team makes modifications (if needed), one student from each team joins a different team and provides helpful feedback by testing the team's revised soap formulation using Tables 2 and 3 | completed before proceeding |
| | **TIP**: *This is a good place to stop* | | |
| **Estimated Time** | **Teacher's Actions [Pedagogical Strategy]** | **Students' Actions** | **Assessment** |
| 60 min | <u>VII. Presentation (Fig.1):</u><br>If resources are available, facilitate student presentations using multimedia (power point, short video, posters, etc.).<br>Stress importance of addressing social/environmental impact (e.g., organic products, recycling containers; benefits to community; and so on).<br>Invite parents, principal, community members, donors to this event.<br>Share evaluation rubric (Table 4) in advance for students to keep in mind as they prepare | Team members take turns to share findings. | Use evaluation rubric (Table 4) |

Figure 1

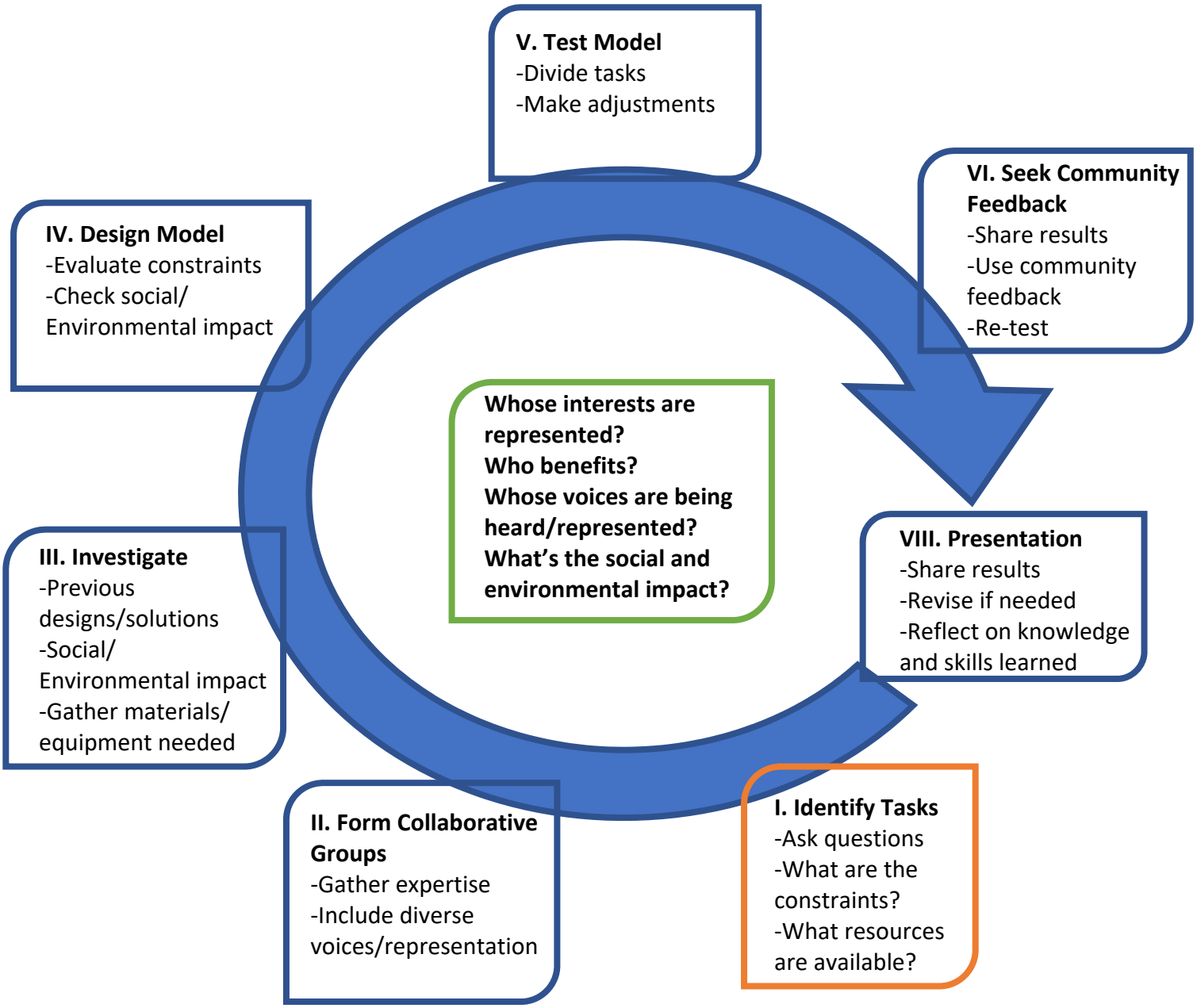
V. Test Model
-Divide tasks
-Make adjustments
VI. Seek Community Feedback
-Share results
-Use community feedback
-Re-test
IV. Design Model
-Evaluate constraints
-Check social/ Environmental impact
Whose interests are represented?
Who benefits?
Whose voices are being heard/represented?
What's the social and environmental impact?
VIII. Presentation
-Share results
-Revise if needed
-Reflect on knowledge and skills learned
III. Investigate
-Previous designs/solutions
-Social/ Environmental impact
-Gather materials/ equipment needed
II. Form Collaborative Groups
-Gather expertise
-Include diverse voices/representation
I. Identify Tasks
-Ask questions
-What are the constraints?
-What resources are available?

Figure 2

**Materials and Ingredients Needed**

- GloGerm cream (8 fl. oz.) $19.50 (glogerm.com)
- Castile soap (organic and unscented plant-based liquid soap base) e.g., Dr. Bronner's Pure-Castile Liquid Soap (Baby Unscented, 32 fl. oz.) $18.46 (Amazon.com)
- Cocoa oils with vitamin E (moisturizes) e.g., Palmer's Cocoa Butter formula (8.5 fl. oz) $5.68 (Amazon.com)
- Aloe Vera oil (moisturizes) e.g., Premium Organic Aloe Vera Oil Pure Health Hair Skin Care Moisturizing (8 fl. oz.) $13.39
- Organic essential oils (fragrance) e.g., Essential Oils Set TOP 8 - Therapeutic Grade Aromatherapy Essential Oils – Pure and Natural - Lavender, Peppermint, Rosemary, Orange, Tea Tree, Eucalyptus, Lemon, Anxiety Relief - Blend Kit (0.33 fl. oz. each) $15.99 (Amazon.com)
- 20 × 2oz Clear Plastic Empty Squeeze Bottles with Flip Cap - BPA-free (set of six $7.99 Amazon.com)
- Black lights e.g., UV LED Black Light Fixtures, Leciel 6W Portable (USB) Blacklight $14.99 (Amazon.com)
- Distilled water $1.00
- Measuring teaspoons
- Plastic graduated cylinders

Table 1

**Instructions:** Use the values below to estimate the approximate volumes and costs for your test. Note that your test vial can only hold 1/5 of the volumes shown in column B below or up to 2 oz (59 ml).

a. Use the values from Column B to calculate 1/5 of those volumes and then enter your answers in Column D.

b. Use the values from Column C to calculate 1/5 of those costs for your test vial. Enter your answers in Column D.

c. If you use additional ingredients, add the volume you used in Column D and the cost in Column E.

d. Add all the costs in Column E to estimate the total cost of your test vial

| **A** | **B** | **C** | **D** | **E** |
|---|---|---|---|---|
| **Regular recipe** | **Volume** | **Approximate Cost ($)** | **Test vial** (2oz/59 ml) **Volume** | **Approximate Cost ($)** |
| Castile soap | ½ cup (125 ml) | 2.20 | 1/5= | 1/5= |
| Distilled water | ½ cup (125 ml) | 0.25 | 1/5= | 1/5= |
| Nourishing oil (Aloe Vera oil or cocoa oil with Vitamin E) | 1 Table spoon (14.8 ml) | 0.80 | 1/5=<br><br>Write type of nourishing oil: | 1/5= |

| | | | | |
|---|---|---|---|---|
| | | | _____ | |
| Essential oil (fragrance) | 25 drops (1.25 ml) | 0.25 | 1/5=<br><br>Write type of essential oil<br>_____ | 1/5= |
| Additional ingredients (e.g. extra nourishing oils) | | | Write type of nourishing oil:<br>_____ | |
| Additional ingredients (e.g. extra essential oils) | | | Write type of essential oil<br>_____ | |
| Additional ingredient (optional) | | | Write additional ingredient<br>_____ | |

**Total Costs:**

**Rationale:** Explain how your team is addressing the four constraints.

Table 2

**Efficiency Test: How well does your liquid soap clean your hands?**

**Instructions:**

a. Rub a dab of GlowGerm cream on your hands

b. Use the blacklight to estimate the percentage of "germs" present. Record your answer.

c. Rub a small amount of your own liquid soap on your hands and wash using the appropriate washing technique.

d. Rinse your hands and then use the blacklight to estimate the percentage of "germs" present after washing. Record your answer.

e. How do your hands feel? Softer, dryer, the same? Use Table 3 to record the moisturizing score.

f. Smell the fragrance of the soap on your hands after washing and use Table 3 to enter your score.

g. After everyone has tried the soap, calculate the average efficiency of your soap.

| | Test 1 | Test 2 | Test 3 | Average Efficiency |
|---|---|---|---|---|
| Estimated % of "germs" observed on hands before and after washing | Before washing:<br><br>After washing: | Before washing:<br><br>After washing: | Before washing:<br><br>After washing: | |

**Summary Findings**: What does your team think about the efficiency of your soap?

Table 3

**Moisturizing, Fragrance, and Cost Assessment Rubric**

**Instructions:**

a. Each team member needs to complete this table after washing their hands. Write comments.

b. After completing tables 2 and 3, write your recommendations below

| | **1 (Poor)** Does not meet or barely meets expectations | **2 (Good)** Meets expectations | **3 (Excellent)** Above expectations |
|---|---|---|---|
| **Moisturizing** (How do your hands feel? Less dry? Dryer? No difference?) | | | |
| **Fragrance** (How does your soap smell? Nicer? Worse? No fragrance?) | | | |
| **Cost** (How much did it cost to make your soap? See Table 1. Is it expensive? Cheap? Average? | | | |

**Findings and Recommendations:**

Keeping in mind that fragrance is influenced by personal preference, discuss your findings and come to an agreement for the final scores and your recommendations.

**Average Efficiency** (enter value from Table 3): **_____**

**Moisturizing Score: _____**

**Fragrance Score: _____**

**Cost Score: _____**

**Describe your recommendations and make sure to address any social/environmental impact**

**b. Re-Test**

Re-test your soap after making the desired modifications. Use the tables to keep track of your changes and new results.

**c. Revised Recommendations**

Discuss your revised findings and come to an agreement for the final scores and your recommendations.

**Average Efficiency** (enter value from Table 3): **_____**

**Moisturizing Score: _____**

**Fragrance Score: _____**

**Cost Score: _____**
**Describe your recommendations and make sure to address any social/environmental impact**

Table 4
**Final Presentation – Evaluation Rubric – Team Members:**
**Total Score: _____**

| **Engineering Design Constraints** | **Needs more (1)** Data tables are incomplete. Some claims have no evidence | **Good (2)** Completed most data tables. Some claims need more evidence. | **Excellent (3)** Completed all data tables. Claims well supported by evidence. |
|---|---|---|---|
| **Efficiency** (How well it cleans hands?) | | | |
| **Moisturizing** (How well?) | | | |
| **Fragrance** (How pleasant?) | | | |
| **Cost** (How inexpensive? | | | |
| **Disciplinary Knowledge** | **Needs more (1)** Demonstrates understanding of some key concepts | **Good (2)** Demonstrates understanding of most key concepts | **Excellent (3)** Demonstrates deep understanding of key concepts |
| | | | |
| **Environmental/Social Impact** | **Needs more (1)** Did not include or only explains some aspects related to environmental/social impact | **Good (2)** Explains well most aspects related to environmental/social impact | **Excellent (3)** Explains all aspects related to environmental/social impact |
| | | | |
| **Team Collaboration** | **Needs more (1)** Not all members equally involved; did not take equal turns presenting; did not | **Good (2)** Most members equally involved; Most members take equal turns presenting; Most | **Excellent (3)** All members equally involved; take turns presenting; listen well to each other's ideas |

| | listen well to each other's ideas | members listen well to each other's ideas | |
|---|---|---|---|
| **Score** | | | |

Online Resources

Online Resources

Brainpop.com

Corona virus: www.brainpop.com/health/diseasesinjuriesandconditions/coronavirus

How soap works: www.brainpop.com/socialstudies/news/howsoapworks

Flu and flu vaccine:

www.brainpop.com/health/diseasesinjuriesandconditions/fluandfluvaccine

Effective Hand Washing Technique

*https://twitter.com/2footgiraffe/status/1241504810932867077)*

National Society of Professional Engineers (2019). Code of Ethics for Engineers. NSPE. *www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf*

STEM Teaching Tools - Practice Brief#55: Why is it crucial to make cultural diversity visible in STEM education

http://stemteachingtools.org/brief/55

STEM Teaching Tools - Practice Brief#53: How to avoid known pitfalls associated with culturally responsive instruction

http://stemteachingtools.org/brief/53

Connecting to the *Next Generation Science Standards*

| Standard: 3-5-ETS1 Engineering Design | |
|---|---|
| 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. | |
| SEP | Classroom Connections |
| Planning and Carrying Out Investigations | Students collaboratively design and test the efficiency of their own liquid soap. |
| DCI | Classroom Connections |
| ETS1.A<br>Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed | Student test different formulations of liquid soap to evaluate their efficiency in accordance to the task criteria and constraints. |

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| solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. | |
| **Science, Technology, Society and the Environment** | Classroom Connections |
| The Influence of Engineering, Technology, and Science on Society and the Natural World | Students evaluate liquid soap formulas with a focus on social and environmental impacts, make modifications, and report findings to the community. |