Lesson Plan & Activities: Next Generation Drug Delivery

Educational Standards:

Next Generation Science Standards:

- HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

ITEEA – Standards for Technological Literacy:

- Standard 9. Students will develop an understanding of engineering design.
- Standard 14. Students will develop an understanding of and be able to select and use medical technologies.

Common Core State Standards:

- CCSS.MATH.CONTENT.HSF.LE.A.4 For exponential models, express as a logarithm the solution to ab^(ct) = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.
- CCSS.MATH.CONTENT.HSF.IF.C.8.B Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)12^t$, $y = (1.2)^t/10$, and classify them as representing exponential growth or decay.
- CCSS.MATH.CONTENT.HSG.GMD.B.4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

Lesson Outline:

<table>
<tr><td>Activity 1: Introduction – Imagination vs Reality</td><td>Time: 15 mins</td></tr>
<tr><td>Description:
1. Read the first prompt with the students.
2. Prompt 1: How would you like to die in a scary movie?
3. Give students 2 minutes to come up with their scenarios. Have a few students share their scenarios.
4. Read the second prompt with the students.
5. Prompt 2: What do people die from in the real-life?
6. Give student 1 minute to think. Then, have a few students share until “cancer” is named at least twice.
7. Ask the students, “who are involved in cancer treatment?”. Give them 1 minute to think. Have a few students share their answers. If “engineer” is one of the answers, go to step 8. If not, follow up with another prompt: “how about an engineer?”.
8. Briefly Introduce the engineering design process by using drug development as an example. The students will share out their thoughts about the seven steps of the engineering design process in developing a drug to treat cancer.</td><td>Materials:
- Projector for prompts
- Math Lab Printout</td></tr>
<tr><td colspan="2">Transition Question 1: Why is cancer so hard to treat?</td></tr>
<tr><td>Activity 2: Background – Why is Cancer So Difficult to Treat?</td><td>Time: 10 mins</td></tr>
<tr><td>Description:
1. Briefly have the students share out their thoughts about transition question 1. Prompt them for the video.
2. Watch the YouTube video: “How do cancer cells behave differently from healthy ones? – George Zaidan” (3:50 minutes): https://www.youtube.com/watch?v=BmFEoCFDi-w
3. After viewing the video, have the students discuss within their group for 2 minutes. Then, have them record their learning in the math lab printout under the section, “Background”.
4. Have two groups share what they recorded.</td><td>Materials:
- Projector for video
- Math Lab Printout</td></tr>
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Transition Question 2: If there are treatments for cancer, why is cancer still the second leading cause of death in the United States?

Activity 3: (Step 1) Identify the Need	**Time**: 15 mins
Description: 1. Have students reflect on transition question 2. 2. Instruct the students to focus on the following prompts when watching the YouTube Video: "Next Generation Drug Delivery System" (~ 8:00 minutes): a. What are the challenges of only using current cancer treatments? b. Is there a need for a new treatment? If so, can you used the ideas presented in the video to engineer a new treatment for cancer. 3. Have the students reflect if there is a need for a new treatment for cancer. (If the students indict "no", have them improve upon the current treatment by using the ideas presented in the video.)	**Materials**: - Projector for video - Math Lab Printout

Transition Question 3: What challenges do we face today with cancer therapy?

Activity 4: (Step 2) Research the Problem	**Time**: 20 mins
Description: 1. Before going to a location with access to computers. Read the transition question 3 with the students. 2. After arriving at the computer lab, reread the transition question 3. Before allowing the students to research on the listed guided research questions listed in the section, "Research the Problem". Have the students record their research learning in the space provided in the section, "Research the Problem". 3. (If applicable; Pre-Calculus: review for modeling with exponential functions) Have the students model cancer cells growth and death with given variables for each treatment as exponential functions. 4. If the students didn't complete their research, have them complete it for homework.	**Materials**: - Computers - Math Lab Printout

End of Day 1 (Short Day)

Activity 5: (Step 3) Brainstorm Possible Solutions	**Time**: 15 min
Description: 1. Group the absent students into groups with two students. To support the students that are absent, briefly, have students share out what problems/needs they have identified about cancer therapies and what they have learned during their research about these problems/needs. 2. Give a short lecture about cancer cells and lipid-based drug delivery systems. Have the students take note in the space provided in the section, “Brainstorm Possible Solutions”. 3. After the lecture, have the students brainstorm possible design for their lipid-based drugs for the following drugs: a. Encapsulate X amount of hydrophobic drugs b. Encapsulate X amount of hydrophilic drugs c. Encapsulate X amount of hydrophobic drugs and Y amount of hydrophilic drugs Give each student a mini whiteboard and a marker as sketch board, and instruct them to draw two of their favorite designs for each drug in the space provided in the section, “Brainstorm Possible Solutions”.	**Materials**: - Projector for lecture - Math Lab Printout - Marker - Mini Whiteboard
Transition Question 4: When you completed your design drawing, evaluate if another engineer can use your design to recreate your drug delivery systems. If not, what other information do you need?	
Activity 6: (Step 4) Engineering Analysis	**Time**: 30 min

Description: 1. Redirect the students. Then, read the transition question 4 with the students. 2. Introduce the cross-section drawing by using a basketball as an example. Focus on the drawing, measurement, scaling, and labeling. Have the students take note in the space provided in the section, “Engineering Analysis”. 3. Introduce the following materials to the students, and have the students measure and record their data in the section, “Engineering Analysis”. a. White marshmallows as lipid head groups b. Twizzlers as lipid tail groups c. Gummy bears as hydrophobic drugs d. Colored marshmallows as hydrophilic drugs 4. Have the students draw the cross-section drawing of their designs in the space provided in the section, “Engineering Analysis”. Instruct the students that one of the cross-section drawings has to be circular. 5. (If applicable) Have students write polynomial functions for the area of the emptied space of the circular cross-section. Then estimate how many drugs can be fitted into the cross-sections. 6. Have the students draw the 3D models of their designs using their cross-section drawings in the space provided in the section, “Engineering Analysis”. 7. (If applicable) Have students write polynomial functions for the volume of the emptied space of the 3D models. Then estimate how many drugs can be put into space. 8. Instruct the students to only build the cross-section drawing and not the 3D model.	**Materials**: - Marshmallows - Twizzlers - Gummy bears - Math Lab Printout
Transition Question 6: (If applicable) Before we make our prototype, is our estimate higher or lower than the actual number of drugs?	
Activity 7: (Step 5) Construct a Prototype	**Time**: 20 min

Description: 1. Give each group three sheets of the white printer paper. Have them draw the perimeter of the emptied space of the cross-section drawing. 2. Instruct the groups to use the perimeter to help them build each of the prototypes. Also, remind the students each lipid needs a head and two tails. Additionally, remind students the lipid cannot overlap in the prototypes. 3. When the vessels are made, have the students place the gummies inside the emptied space. Then, using their phone, take a photo of each model.	**Materials**: - Marshmallows - Twizzlers - Gummy bears
Transition Question 7: None; direct the students to evaluate their model using the rubric found in the next section.	
Activity 8: (Step 6) Evaluate/Manufacture a Final Product	**Time**: 5 min
Description: 1. Have the students evaluate each of their cross-section models using the rubric found in the section, "Evaluate/Manufacture a Final Product". 2. Have the students record what improvement(s) is/are needed in the space provided in the section, "Evaluate/Manufacture a Final Product".	**Materials**: - Math Lab Printout
Transition Question 8: None; direct the students to use the rubric and their improvement reflection to redesign.	
Activity 9: (Step 7) Redesign as Needed	**Time**: 15 min
Description: 1. Have the students redesign their model by using the rubric and their improvement reflection as guides. 2. Instruct the students to take a picture of each prototype they made until a final product is produced. 3. Instruct the students to take a picture of each final product.	**Materials**: - Marshmallows - Twizzlers - Gummy bears - Math Lab Printout

Transition Question 9: None; direct the students to complete self-assessment and reflection.

Activity 10: Self-assessment and Reflection	**Time**: 5 min
Description: 1. After the students build their final product, have the students completed the section, “self-assessment and Reflection”. If the students are not done, have the students complete it for homework. 2. (If applicable) Have students do math problems related to the activity (the relationship between area and volume) for homework.	**Materials**: - Math Lab Printout
End of Day 2 (Long Day)	

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