Design-a-Device:
Cells as Building Blocks
Conceptualizing a 3D BioPrinter

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Subject/Grade: **Life Science/7**
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ETP Type: **Classroom, in-person**
(classroom or PD; distance learning, hybrid or in-person)

ETP Section Guide · Rubric and Checkbric · Published ETPs
ETP Review Prompts
Active STEM Learning and 21st Century Skills

Abstract (~150 words)

3D bioprinting is an emerging field that seeks to address a shortage of compatible organ donors. Within the past five years alone considerable research has been conducted to develop a low-cost 3D bioprinter that does not sacrifice quality (especially print resolution) for cost. As bioprinters become cheaper, classroom teachers have a unique opportunity to introduce students to technology that has the potential to save lives, and to experiment with ways to use and improve it. Furthermore, students develop self-esteem, self-efficacy, and comfort in content matter through repeated use of laboratory equipment because they are able to directly experience and interact with the equipment. This ETP provides students an introduction into the world of 3D bioprinting by having them first conceptualize what parts would be required to make a device that can print cells into larger structures. From there, students are asked to consider the applications of such a device. This sets the stage for students to understand the key parts of a 3D bioprinter: the electronics, the mechanics, and the programming to run it; and to consider the implications of such a device, especially in medicine.

Focal Content & Supporting Practices

Next Generation Science Standards
DCI: MS-LS1 From Molecules to Organisms: Structures and Processes
MS-LS1-1: All living things are made up of cells, which is the smallest unit that can be said to be alive.
MS-LS1-3: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions
CCC: Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
SEP:
Asking Questions and Defining Problems

21st Century Skills and Applications (1 - 2 bullets)

- *Creativity and Innovation*: Students will imagine new ways of putting together devices for 3D bioprinting, and potential applications of the device.
- *Collaboration*: Students will discuss and build off each others' ideas in groups.
- *Problem Solving*: Students will be given constraints (cells must be alive, in 3D structures) for the design project.

Measurable Objective(s)

- Students will be able to collaborate and use design thinking to imagine or adapt an existing technology to address real-world problems.
- Students will be able to identify structures that they think would be part of a 3D bioprinter.

Formative Assessment(s)

Journal Prompt
Brainstorm
Reflection

Summative Assessment(s)

Group Sketch
Group Business Pitch

Fellowship Description (300-500 words)

The Basic and Applied Sciences and Engineering (BASE) initiative at Stanford is a collaboration between science and engineering research labs and the Irene Moore Children's Heart Hospital at the Lucille Packard Hospital for Children at Stanford. As part of the initiative, Dr. Skylar-Scott's lab explores how 3D bioprinting can be advanced to print viable cardiac tissue.

My fellowship with the Skylar-Scott Lab is focused on creating an interactive curriculum for a summer camp for middle school students with single ventricular disease to explore the construction and applications of a 3D bioprinter. One of the goals of this project is to help students see the interdisciplinary nature of science: 3D bioprinting relies on the intersection of biology and engineering. The printer itself relies on mechanical and electrical aspects, as well as code to run. The products of the printer have implications for synthetic biology and tissue engineering, as the hope is to address the shortage of compatible organ donors by 3D printing organs. Another is to provide these students with hope.

Through the fellowship, I collaborated with the team to translate the experiences of building the 3D bioprinter and understanding its applications into a 5-day lesson sequence that can be used to teach the middle school students at the camp, and also be adapted by middle school teachers who are interested in introducing the concept of 3D bioprinting to their students.

Developing the curriculum and activities for the camp involved reaching out to and communicating with individuals on the team with varying degrees of expertise in order to make sense of expectations and desired goals. It also involved me confronting my own areas of growth in coding and identifying paths to learn and understand coding for the sake of being able to design an effective curriculum to teach it. Within the lab, a number of skills and opportunities allowed success: multiple iterations as opposed to immediately jumping to a single, finished model; seeking expertise from different members of the team to fill gaps in knowledge; being flexible!

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

Our team was fortunate enough to be invited to a camp for students with Single Ventricle Disease (SVD) and introduce students to 3D Bioprinting in a short 40 minute lesson. The students ranged from highschool to college in age, but all demonstrated a deep understanding of heart anatomy and their disease. Dr. Skylar-Scott leveraged their knowledge towards an understanding of 3D bioprinting, its current limitations, and the hopes and goals for research, especially related to Children's Heart Disease. After the workshop, we had an opportunity to sit down and talk to the young individuals at the camp,

and they shared with us their interests, their hopes and dreams, and their frustrations with their science classes (ranging from textbook-focused lessons to teachers not believing and/or dismissing their knowledge of heart anatomy). Though brief, the interaction with these students fortified the need for our team's goals for the low-cost 3D bioprinter: to make 3D bioprinting research more accessible; to allow secondary classrooms access to equipment used in cutting-edge research; but, most importantly, to empower the individuals that this technology is being developed to help by placing it into their hands through the SVD camp, where they will have space to share their knowledge and to share their own hopes and dreams for research in heart disease. It is a strong reminder to me to acknowledge the funds of knowledge students enter the classroom with, and leverage these funds to elevate students to become active participants in their own learning.

END of ETP Proposal!

Instructional Plan (This is the bulk of your ETP and may take several pages.
Plan something that can be done in-person.

Lesson Timeline	
Day 1: 55 min 15 min: Journal Prompt 5 min: Individual Brainstorm 10 min: Group Brainstorm 20 min: Group sketch 5 min: Prep for Group Presentations	**Day 2: 55 min** 35 min: Group Presentations 15 min: Direct Instruction: What is a 3D Printer? 5 min: Conclusion: Revise what you know!
Design-a-Device: Lesson Plan	

Additional Supports
Tools to meet the needs of all learners (SEL, distance learning, ELL, SPED)

SEL: Group Share-out Expectations (See Slide 4) **ELL:** Sentence starters for group work **Distance Learning:** Brainstorms and discussions can be conducted online via breakout rooms and jamboard or other apps that allow groups to collaboratively document their ideas. **SPED:** Strategic grouping; opportunities to sketch and/or write

Materials
Include links to all files within this ETP

Handout: Sentence Starters *Alternative Discussion*: Give One Get One *Handout*: Design-a-Device Student Instructions (includes *Sketch Checklist* and *Presentation Rubric*) *Handout*: Audience Tool *Teacher Resource*: What is 3D Bioprinting? [Teacher information sheet] *Teacher Resource*: Conceptualizing a 3D Bioprinter Slide Set *Enrichment/Teacher Resource*: Low-Cost 3D Bioprinting [Stanford RET Symposium Presentation] Lesson Plan pdf: Design a Device

References

Teaching Strategy: Give One, Get One | *Facing History*, Facing History & Ourselves, www.facinghistory.org/resource-library/teaching-strategies/give-one-get-one.

Miller, Jordan S. "The Billion Cell Construct: Will Three-Dimensional Printing Get Us There?" *PLoS Biology*, vol. 12, no. 6, 17 June 2014, pp. 1-9, doi:10.1371/journal.pbio.1001882.

Ji, Shen, and Murat Guvendiren. "Complex 3D Bioprinting Methods" *APL Bioengineering*, vol 5, 11 March 2021, doi:10.1063/5.0034901

Keywords

3D Bioprinting, Structure and Function, Engineering Design

END of ETP!

Final Draft due: 3 days before end of Fellowship