

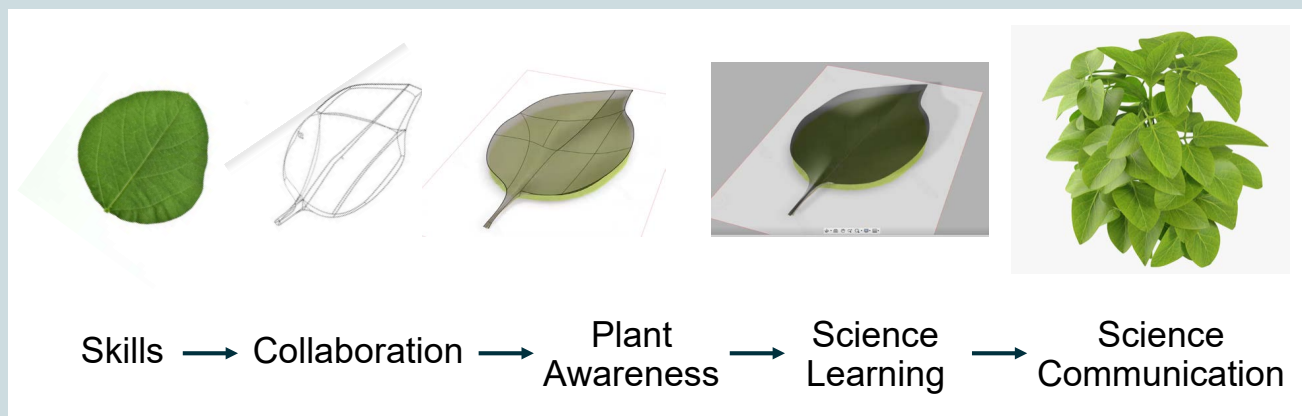


Student Achievement Through Productive Failure

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Introduction

Interactive project-based learning that experiences productive failure provides the opportunity for students to problem solve novel topics and potentially fail at finding the solution. Through explanation, elaboration, comparison of iterations, refinement, and implementations, students can be better prepared to solve future problems. Our study examined the benefits of productive failure on high school students from both formal and informal learning environments working in collaborative teams to design and create 3D plant models. This STEAM project integrates science, design, and technology through innovative learning experiences in plant and agricultural science using emergent technologies. Students work together in collaborative teams of self-identified science, technophile, and art students to create 3D models of plants used in research at the Donald Danforth Plant Science Center (DDPSC). Students learn about scientific research, the importance of plants in our society, and practice science communications skills. To create the 3D models, students must learn-by-doing to become proficient in using previously unfamiliar 3D modeling software.



Objectives of This Study

1. To determine the type of challenges students faced conducting the activity.
2. To identify the actions taken by students to confront these challenges.
3. To identify positive outcomes from facing challenges.

Methods

- Students work in teams of self-identified science, technophile, and art students, with teachers as facilitators.
- Students use videos to self-train on how to use the 3D modeling programs (e.g., Tinkercad and Fusion 360).
- Teams create 3D models of plant parts from species under research at the DDPSC and receive scientist advice on model accuracy and research content.
- Students learn about the application of 3D models through augmented and virtual reality immersive experiences (AVR).
- Students give presentations of their projects in public/scientific events to practice their science communication skills.

To investigate productive failure in this project, we use a mixed-methods assessment approach. Students answer pre and post reflection questions about challenges they face and how they overcome these challenges. The student responses are coded by two researchers and grouped by main themes.

Preliminary Results

Pre and Post responses from 36 students

Pre-reflection Question:

Describe a time when you faced a challenge in class and how did you overcome it?

“Sometimes, I feel lost or don’t understand class material, reaching out to classmates or teachers for help is the best way to overcome my problem.”

“In a group project, one student wasn’t doing their share of work, so we had a meeting and discussed our expectations of each other.”

Post-reflection Question:

Describe any challenges you encountered during the project. What did you do when you encountered these challenges?

“One big challenge I encountered...was learning how to use Fusion360. There was a pretty steep learning curve. To overcome these challenges, I talked with teammates and watched videos.”

“Communication was not the easiest considering we all have preferred methods of communication. We ended up creating a group chat.”

Counts of Main Themes

Challenge	Pre		Post	
Main Codes	Counts	%	Counts	%
Challenge	2	3.5		
Learning New Skills	4	7.0	40	67.8
Communication	7	12.3	7	11.9
Everything			1	1.7
Difficulty in Understanding	26	45.6	4	6.8
Concepts/Materials in Schools				
Intrapersonal Issues	10	17.5	3	5.1
Workload	3	5.3		
Other	5	8.8	2	3.4
No Challenge			2	3.4

Overcoming Challenge	Pre		Post	
Main Codes	Counts	%	Counts	%
Overcoming Challenge	2	2.4		
Asked Other People for Help	37	44.6	11	26.2
Outside Resources	4	4.8	9	21.4
Made Adjustment	9	10.8	7	16.7
Communication/Confrontation	4	4.8	4	9.5
Adjusted Personal Values	1	1.2		
Persistence/Continued Effort	22	26.5	10	23.8
Prioritize Mental Health	3	3.6	1	2.4
Other	1	1.2		

Examples of 3D Models

Chlamydomonas (*Chlamydomona reinhardtii*)



Common milkweed (*Asclepias syriaca*)



Summary

- The challenges the students faced included difficulties using the 3D modeling software and communicating and coordinating work with their assigned team.
- Many students reported being able to overcome these challenges through seeking outside resources and guidance and openly communicating their expectations and goals.
- Through perseverance students gained skills and knowledge, and generated research products.

What is Next?

- Data collection from more schools, including rural schools.
- Analysis comparing pre and post responses across schools.

Acknowledgments

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