3D plants: Deploying Emerging Technologies to Revolutionize STEAM+Ag™ Education

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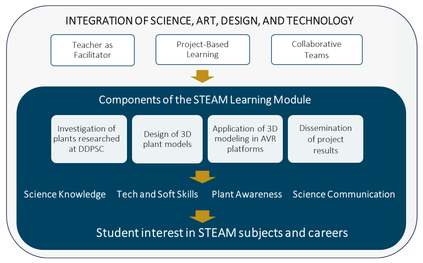
STEM education is a cohesive interdisciplinary approach to learning where academic concepts across disciplines are coupled with real-world lessons to develop student STEM literacy. STEM education, however, faces a challenge due to the disconnect between innovation and design, which are critical elements to help communities face 21st-century global challenges. The Education Research and Outreach Lab (EROL) at the Donald Danforth Plant Science Center (DDPSC) aims to inspire the next generation of plant scientists through STEAM+Ag (Science, Technology, Engineering, Art, Math, and Agriculture) initiatives. Our ITEST project examined how urban and rural high school students benefited from innovative learning experiences that:

1. Integrate art/design into STEM plant science education.
2. Foster knowledge and appreciation of plant science among students.
3. Apply AVR technology to advance plant science education using novel tools and methodologies.
4. Inspire interest in STEM careers among students and provide them with skills for a future STEM career.

This experience inspires creative learning, promotes critical thinking and problem-solving skills, supports innovation concepts, and allows students to connect to real-life situations, which can impact their career paths.

Teaching Module

We created a STEM project-based module where instructors were facilitators and students worked in teams of self-identified science, technophile, and art students. The module consists of four components. See figure.



Assessments Mixed-methods

Qualitative: Pre/Post Reflection questions on understanding the intersection of art and design with science, STEAM learning, skills outcomes, and changes in interest in STEAM careers. (Deductive coding)

Quantitative: Pre/Post Survey that gauges student perceptions of STEAM disciplines and careers. This survey is an adaptation of the STEM Semantics Survey, a highly reliable tool developed by Tyler-Wood et al. in 2010.

Qualitative and quantitative: Pre/Post Survey on plant science awareness. Plant Disparity Index (PAD-I) (Parsley et al. 2022)

Participants

Type of Institution	No. of Institutions	No. of Students
Urban schools	7	119
Rural schools	6	124
Public schools	8	176
Private schools	3	46
Informal programs	2	21
Total institutions	13	243
Cities/Towns/States	6 cities/towns in MO 2 city/town in IL	41 MO 202 IL

Education Technology Program

STELAR Project Site

Collaborators

zSpace

Christopher Topp
Principal Investigator
Donald Danforth Plant Science Center

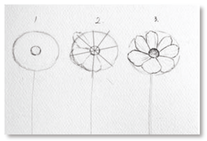
DONALD DANFORTH PLANT SCIENCE CENTER
DISCOVERY | COMMUNITY | IMPACT

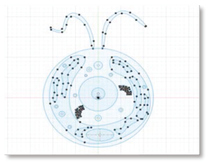
ITEST Award No. 1949463

High school students acquired plant science expertise, developed collaboration, 3D modeling, and communication skills, and cultivated interest in STEAM careers through integrating science, design, and technology.

Creativity, collaboration, and science communication

Concept art

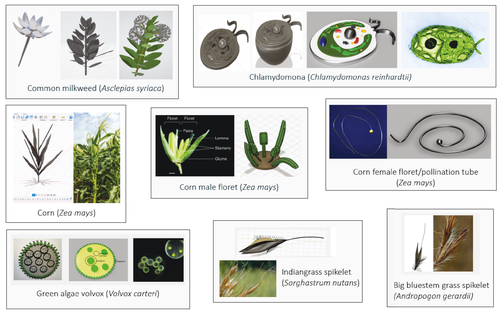




3D modeling

Presentations

3D plant models



Handouts

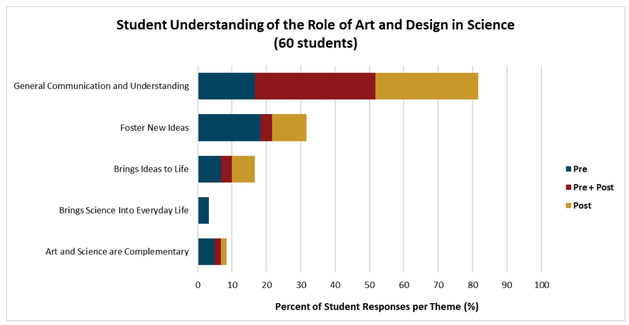
Productive Failure

Student Challenges	Pre-Survey		Post-Survey	
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 concepts/materials in school	26	**45.6**	4	6.8
Intrapersonal issues	10	17.5	3	5.1
Workload	3	5.3		
Other	5	8.8	2	3.4
No Challenge			2	3.4

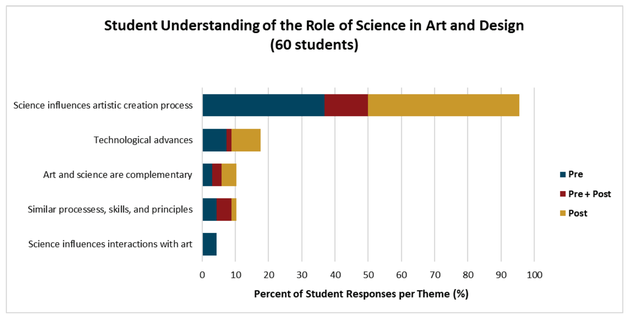
Overcoming Challenge	Pre-Survey		Post-Survey	
Main Codes	**Counts**	**%**	**Counts**	**%**
Overcoming challenge on their own	2	2.4		
Asked other people for help	37	**44.6**	11	**26.2**
Outside resources	4	4.8	9	**21.4**
Made adjustment	9	10.8	7	16.7
Communication/confrontation	4	4.8	4	9.5
Adjusted personal 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		

Student quote: "*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.*"

Understanding the intersection of art and design with science

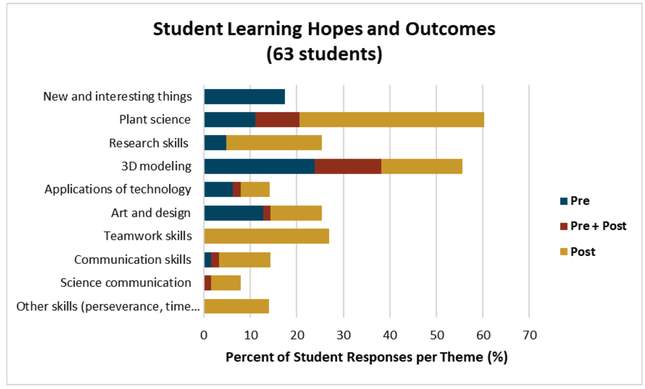


Student quote: *"Being able to visually represent elements of an important scientific model that the average person may not understand under strictly scientific jargon is important for advancing the general public's understanding of science."*



Student quotes:
"Science shapes how art is made and things are designed."
"Science is an inspiration for art."

Learning hopes and outcomes



Student quotes on the most important outcomes gained:
"Learning about my plant and the unique benefits it could have in the future with climate change."
"Gaining more skills with computers and technology."
"Working with a group and presenting with a group is one of the most important outcomes as it is one of the most common skill in the professional world."

Changes in student interests in STEM careers

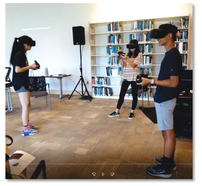
Themes on changes in STEAM career interests	No. Students	%
Statements expressing positive change	**27**	**39.7**
More interest in science careers *	10	14.7
More interest in STEAM careers **	12	17.6
More interest in STEAM careers with other subjects	1	1.5
More interest in design careers	3	4.4
More interest in non-STEAM careers	1	1.5
Statements expressing no change	**41**	**60.3**
Already interested in science careers	4	5.9
Already interested in STEAM careers	4	5.9
Already interested in art/design careers	1	1.5
Already interested in non-STEAM careers***	8	11.8
Total students	**68**	**100**

* Six students interested in plant science. ** One student interested in plant science.
*** Three students acknowledged that the module helped them reinforce their interest in non-STEAM careers.

3D modeling applications in AVR

Augmented Reality (AR) with zSpace

Virtual Reality (VR) with



Game created by EROL.

Acknowledgments

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References

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