3D Plants: Students build AVR plant models to understand the role of design in STEM

Common milkweed

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MISSION

Improve the human condition through plant science.

How to effectively engage students (K-16) in authentic STEM research

in formal and informal learning environments to recruit

the next generation of diverse STEM and AgTech scientists and leaders

Formal & Informal Education in STEAM+Ag

Curriculum opportunities

Professional development

Equipment loan rotation

Outreach

No cost

Education research

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Science learning

Source: ESB Professional

Challenges in Science learning:

- memorization
- lack of understanding of the reality of abstract concepts
- overload of content
- no connection to real lives

How can we improve students' attitudes towards STEM?

How can we improve student's interest in STEM careers?

Plant science

How can we promote students' interest in plant and agricultural science?

Education Technology

Enriching STEAM Education Through Technology

The Education Technology Program uses cutting-edge technology to engage and inspire students to pursue STEAM careers. Immersive educational experiences are offered through augmented and virtual reality, 3D modeling, computer gaming, and more, making science accessible to all.

Education Technology Program

Technology is part of our daily lives

Technology-enabled learning

Emergent technologies & applications

STEAM teaching model

Pedagogical strategies

Interactivity

Interdisciplinary subjects of STEAM

Lin & Tsai, 2021

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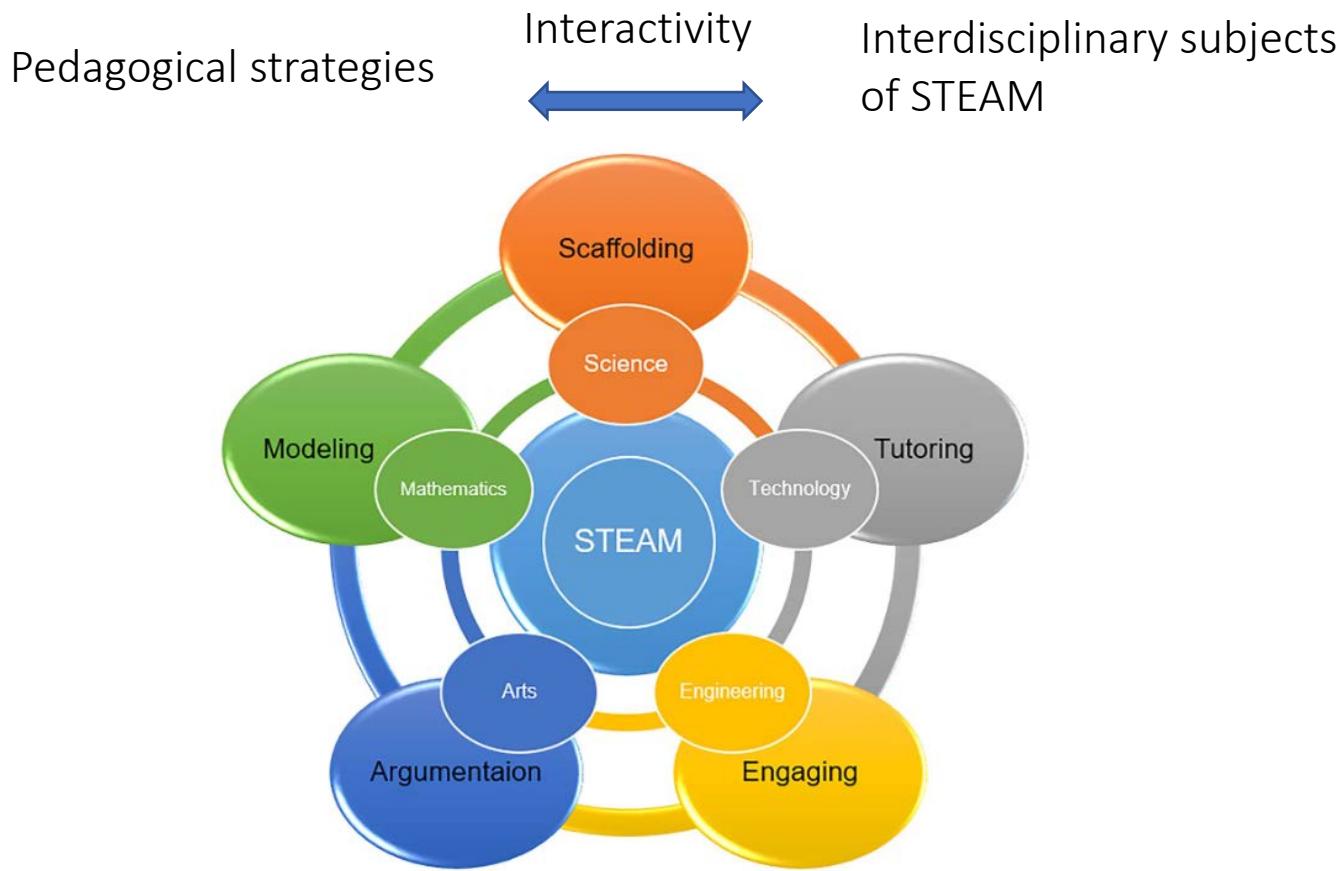
Integration of plant science, technology, and art/design

Plant Science
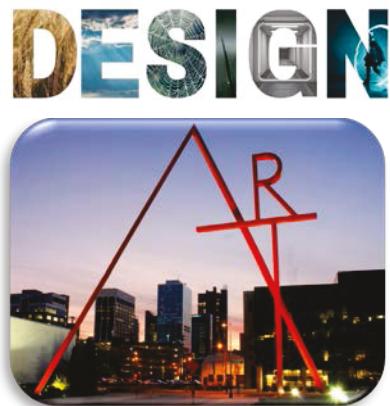
Art/Design
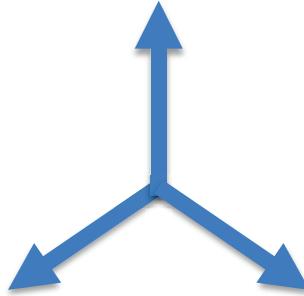
Technology

3D Plants: Students build AVR plant models to understand the role of design in STEM

Goal
To address the disconnect between science, design, and technology at the high school level using 3D plant modeling

Objectives

1. Integrate art/design into STEM education (STEAM)

2. Foster plant science knowledge

3. Apply augmented and virtual reality (AVR) technologies

4. Inspire interest in and provide skills for future STEAM careers.

Next Generation Science Standards
National Coalition for Core Art Standards

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3D modeling

Object-based learning approach

3D activate learning

Plant 3D modeling

Student benefits
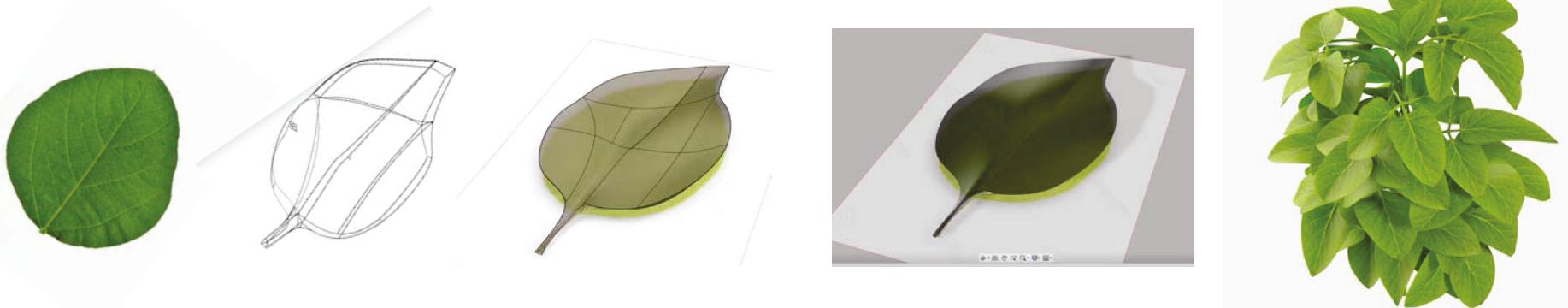
Skills ⟶ Collaboration ⟶ Plant awareness ⟶ Science learning ⟶ Science communication

3 weeks - semester

Teams made of art-, science-, tech-oriented students

+
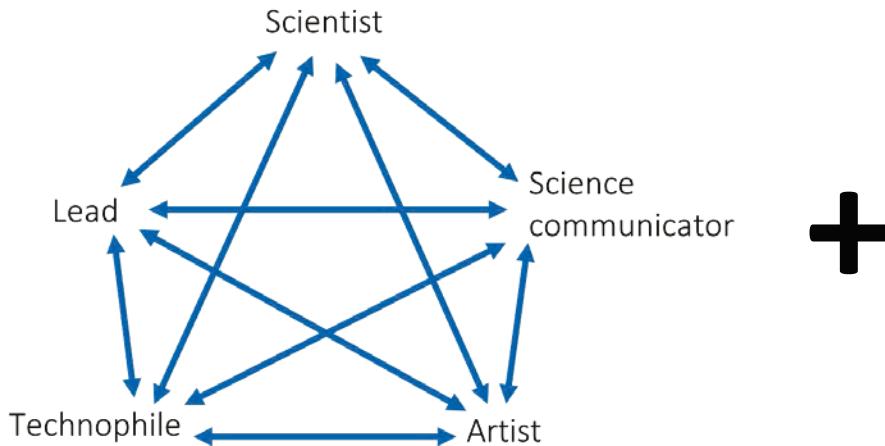
Support:

- Teacher
- Protocols, training
- Scientists
- 3D modeler

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# Plant species and plant parts


Wheat *(Triticum aestivum)*	Flower		**Scientific advisors:** Dr. Blake Meyers (BMeyers@danforthcenter.org) Ryan DelPercio (RDelPercio@danforthcenter.org) Sebastien Belanger (SBelanger@danforthcenter.org)
Barley *(Hordeum vulgare)*	Flower		Lab website
Soybean *(Glycine max)*	Root nodules		**Research Program:** To enable the hybridization of entirely new crops by understanding the mechanisms underlying pollen development.
Oat *(Avena sativa)*	Flower		

The concept art
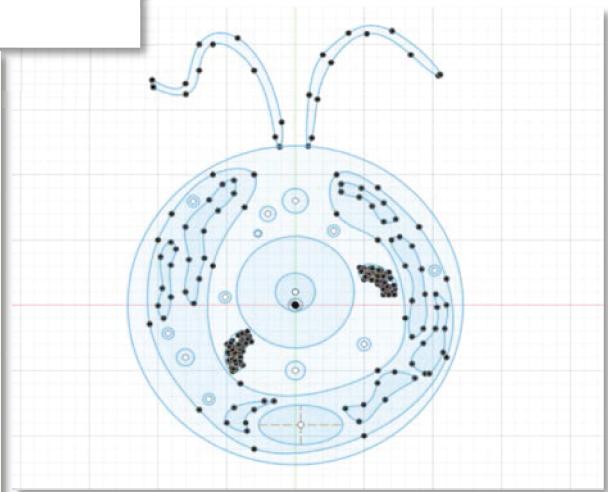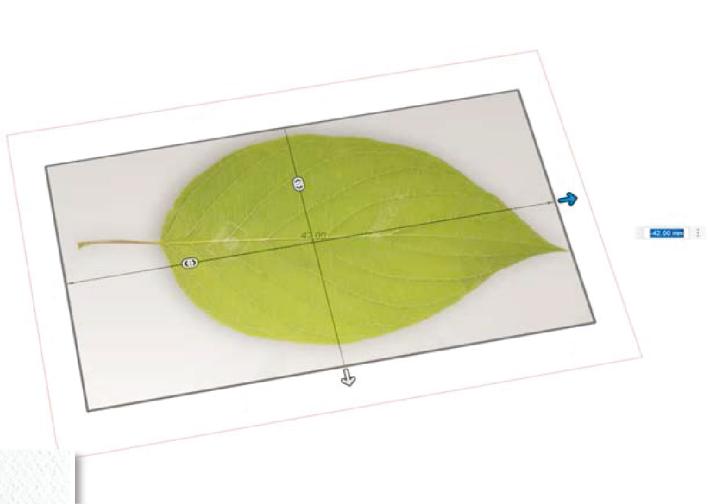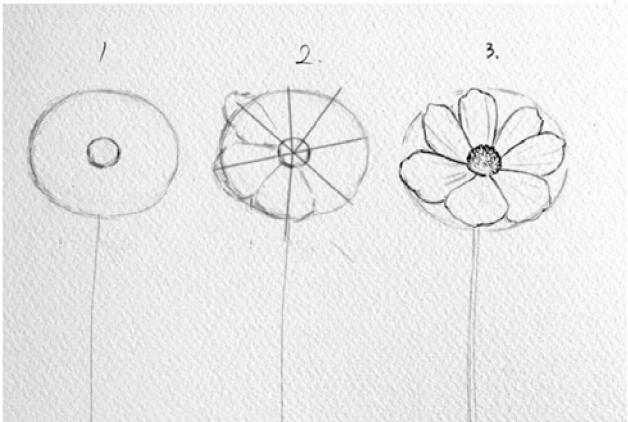
Training in 3D modeling

Nate Ly, 3D modeling advisor (high school intern)
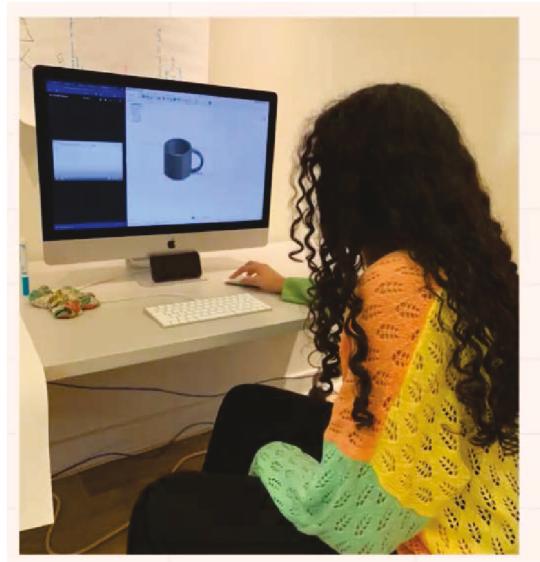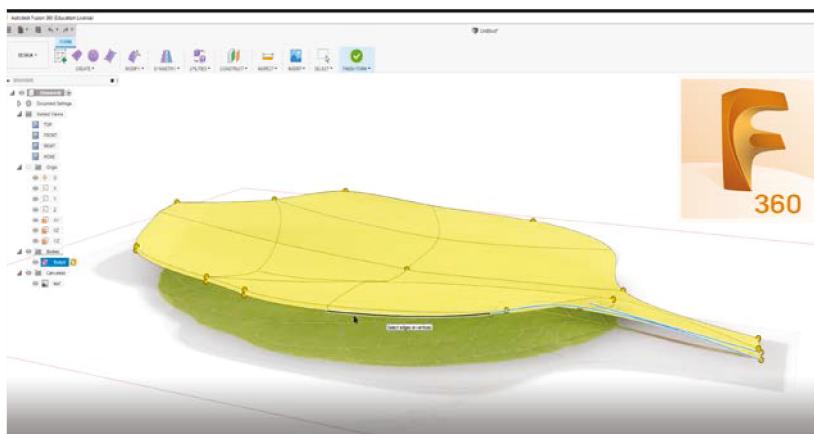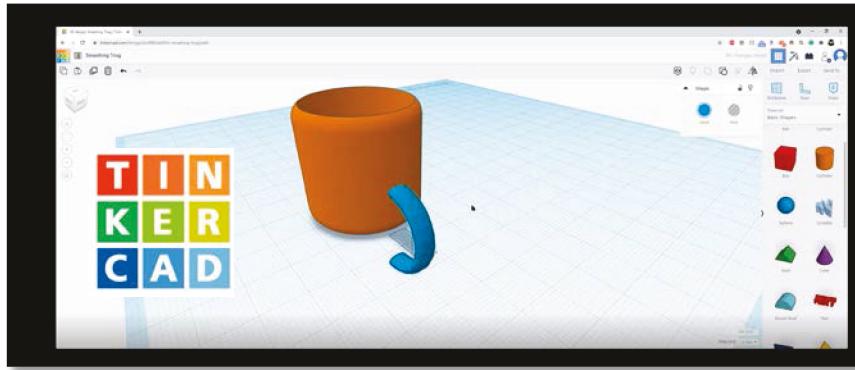
Documentation of the process of 3D model creation

Investigation of species biology and importance

One-page worksheet

- Plant biology: life form, habitat, distribution, reproduction

- Importance: e.g., fix nitrogen, crop, climate adaptation

- Danforth research: e.g., seed dispersal, model plant

Applications of 3D models in AVR

Augmented Reality (AR)

Virtual Reality (AR)

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Project dissemination

Products
   3D models
   Presentation, video, or poster
   One-page document

Project presentations
   School
   Scientific events
   Public events

Collaboration with zSpace

Student assessments

Parent consent
Student assent

- Pre/Post Survey on student perceptions of STEAM disciplines and careers
  (Adapted from the STEM Semantics Survey by Tyler-Wood et al. 2010)

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

- Pre/Post Reflection questions about the role of science in art/design and vice
  versa, benefits, memorable moments, productive failure, etc.

Project in numbers (Summer 2020 – Spring 2023)

High schools
Private: 8
Public: 16 (15 urban, 1 suburban)

Formal settings (115 students)
Class project
STEM program Spark!

Informal settings (21 students)
Danforth Summer Internship
YES program – St. Louis Science Center

No. of high school students: 136

Females: 54.8%
Males: 36.3%
Prefer not to answer: 8.9%

Adults (≥ 18 years): 26.8%
Minors: 73.2%

Students	First choice
Science-oriented	28%
Tech-oriented	23%
Art-oriented	28%
Other	21%

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The students

Race/Ethnicity	No. students	%
American Indian/Alaska Native	2	1.7
Asian	22	18.5
Bi-racial	3	2.5
Black/African American	19	16.0
Hispanic/Latino	8	6.7
Native Hawaiian/Pacific Islander	1	0.8
White	64	53.8
Total	119	100

Grade	No. of students	%
7	1	0.8
8	2	1.7
9	11	9.1
10	7	5.8
11	48	39.7
12	52	43.0
Total	121	100

Student exposure to AR/VR

Experience with augmented / virtual reality (103 students)

Yes 52%
No 51%

3D modeling experience (103 participants)

Yes 47%
No 54%

Technology used (60 responses)	%
Phone Apps	33.3
Head mounted devices / Glasses	56.7
Consoles (e.g., Playstation)	3.3
Computer (e.g., websites)	6.7

Educational setting for 3D modeling experience

Formal settings (classes):
    3D Printing
    Shop
    Math
    Marketing/Product design
    STEM

Informal settings:
    Robotics
    Maker space
   Girl scouts
    Geocatching
   Self taught

3D plant models

Common milkweed (*Asclepias syriaca*)

Chlamydomona (*Chlamydomonas reinhardtii*)
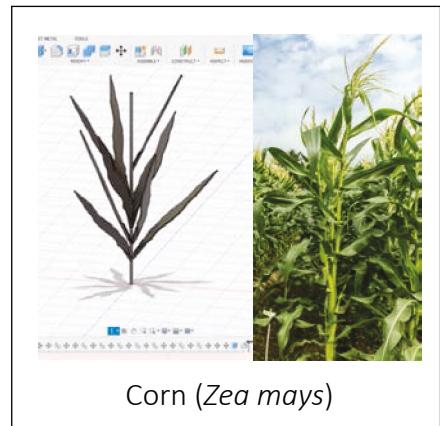
Corn (*Zea mays*)
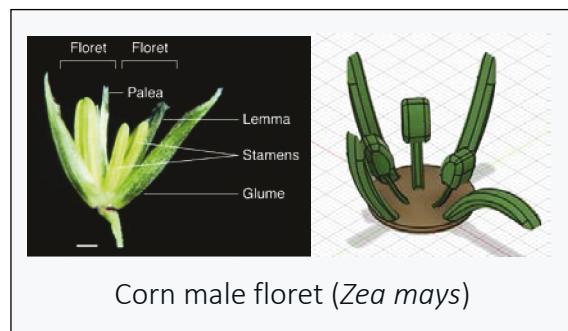
Corn male floret (*Zea mays*)
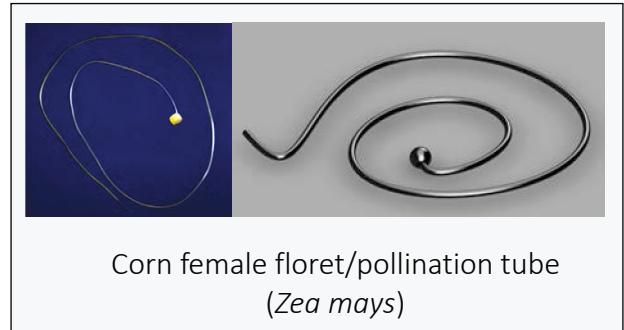
Corn female floret/pollination tube
(*Zea mays*)
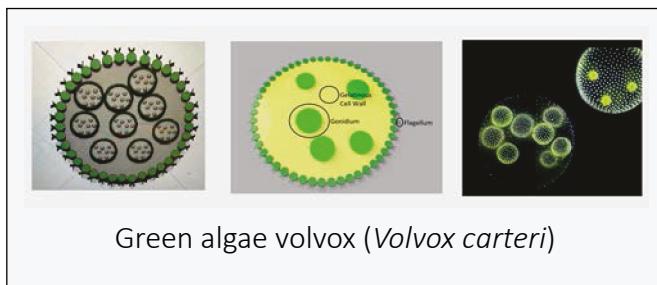
Green algae volvox (*Volvox carteri*)

Big bluestem grass spikelet
(*Andropogon gerardii*)

Indiangrass spikelet
(*Sorghastrum nutans*)

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STEAM Semantics Survey

Pre/Post Survey on student perceptions of STEAM subjects and careers
(Adapted from Tyler-Wood et al. 2010)

To me, SCIENCE is:

	1	2	3	4	5	6	7	
Fascinating	○	○	○	○	○	○	○	Mundane
Appealing	○	○	○	○	○	○	○	Unappealing
Exciting	○	○	○	○	○	○	○	Unexciting
Means nothing	○	○	○	○	○	○	○	Means a lot
Boring	○	○	○	○	○	○	○	Interesting
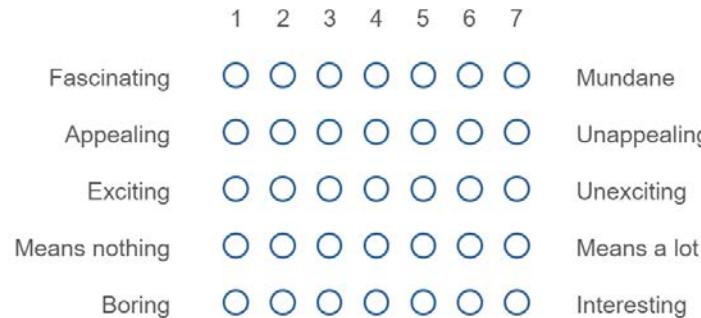
To me, TECHNOLOGY is:

To me, ENGINEERING is:

To me, MATHEMATICS is:

To me, DESIGN is:

To me, CAREER in science, technology, engineering, art, or mathematics (is):

5 questions/subject
30 questions/student

Changes in interests in STEAM subjects and careers

Counts of type of change per subject

Students: 60

Total responses per subject: 300

* Wilcoxon test p < 0.01

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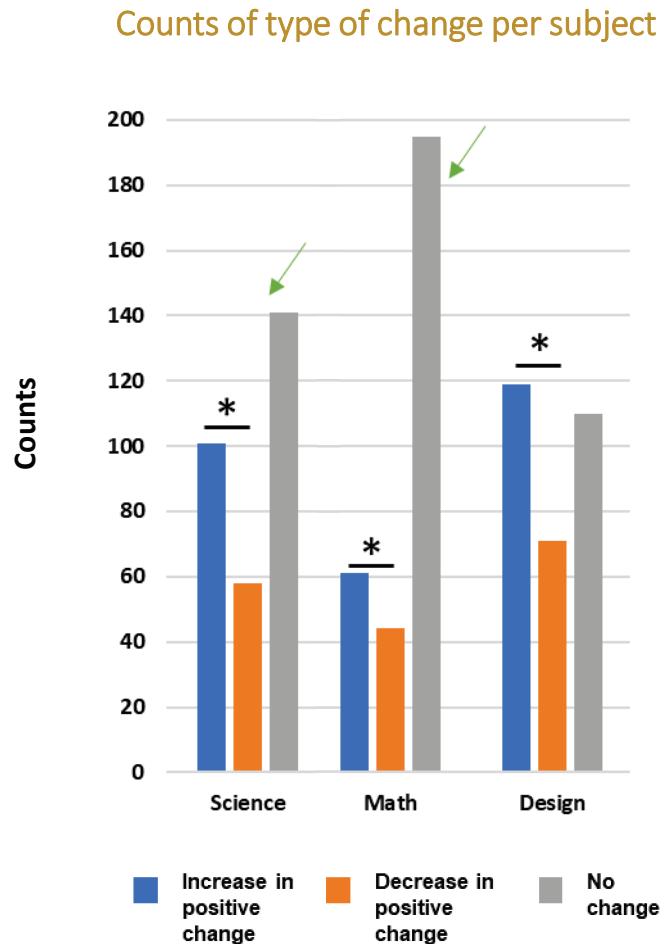
Plant Awareness Disparity Index

Pre/post surveys

25 questions in 6 subscales

4 points Likert style scale:
  "completely disagree"
  "somewhat disagree"
  "somewhat agree"
  "completely agree"

Parsley et al. 2022

SUBSCALES

Caring for or Investment in Plants

Necessity of Plants/ Importance of Plants

Plants Better than Animals

Animals Better than Plants

Positive Affect

General Attention

46 students

Written Reflections

How does art and design play a role in science?

How does science play a role in art and design?

Pre/Post responses: 30 students

Qualitative analysis

Coders:
Kaitlyn Ying (undergraduate intern)
Michelle Arellano, Ph.D. (collaborator)
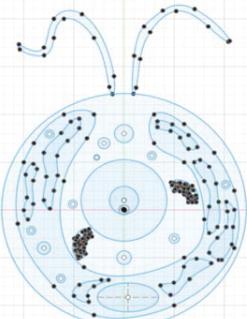
Written Reflections

How does art and design play a role in science?

Main codes	Pre counts	Post counts
Foster new ideas including technological advances and creation of tools	5	3
Communication and further understanding (e.g., visual representation, understanding of scientific content, makes science accessible to all, communicate ideas between scientists)	17	18
Aid in problem solving	1	
Greater appreciation of science	1	
Interactivity / Brings ideas to life		3
Complementarity between art/design and science		1

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Written Reflections

How does science play a role in art and design?

Main codes	Pre counts	Post counts
Science influences artistic creation process (e.g., design logistics, inspire artistic ideas, innovation, new type of art)	12	14
Similar process, skills, and principles	2	2
Technological advances	2	3
Science influences interactions with art	3	

Next Steps

Enroll students from rural schools

Continue the coding of the reflection questions

Project dissemination

- Planting Seeds of STEM, May 20th, 2023
- Publications

zSpace collaboration

Acknowledgements

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