3D plants: Integrating science, technology, and design in STEAM+Ag education using emergent technologies

Common milkweed

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Science Learning

Source: ESB Professional

Challenges in science learning:

- memorization
- abstract concepts
- overload of content
- no application to real live situations
- disconnect with other disciplines

Importance:

- science literacy
- scientific thinking
- becoming a scientist
- accessible to all

(Mansfield & Reiss, 2020; National Academies of Sciences, Engineering, and Medicine, 2021; Burhanuddin et al., 2021)

Technology and Design

Technology is part of our daily lives

Technology-enabled learning

Nontraditional/interdisciplinary instruction

Emergent technologies & applications
- Augmented and virtual reality
- Digital design

Closing the digital use and access divide

Need of 21st century skills

Workforce

(Leavy et al., 2023; U.S. Department of Education, 2024)

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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Pedagogical STEAM Model

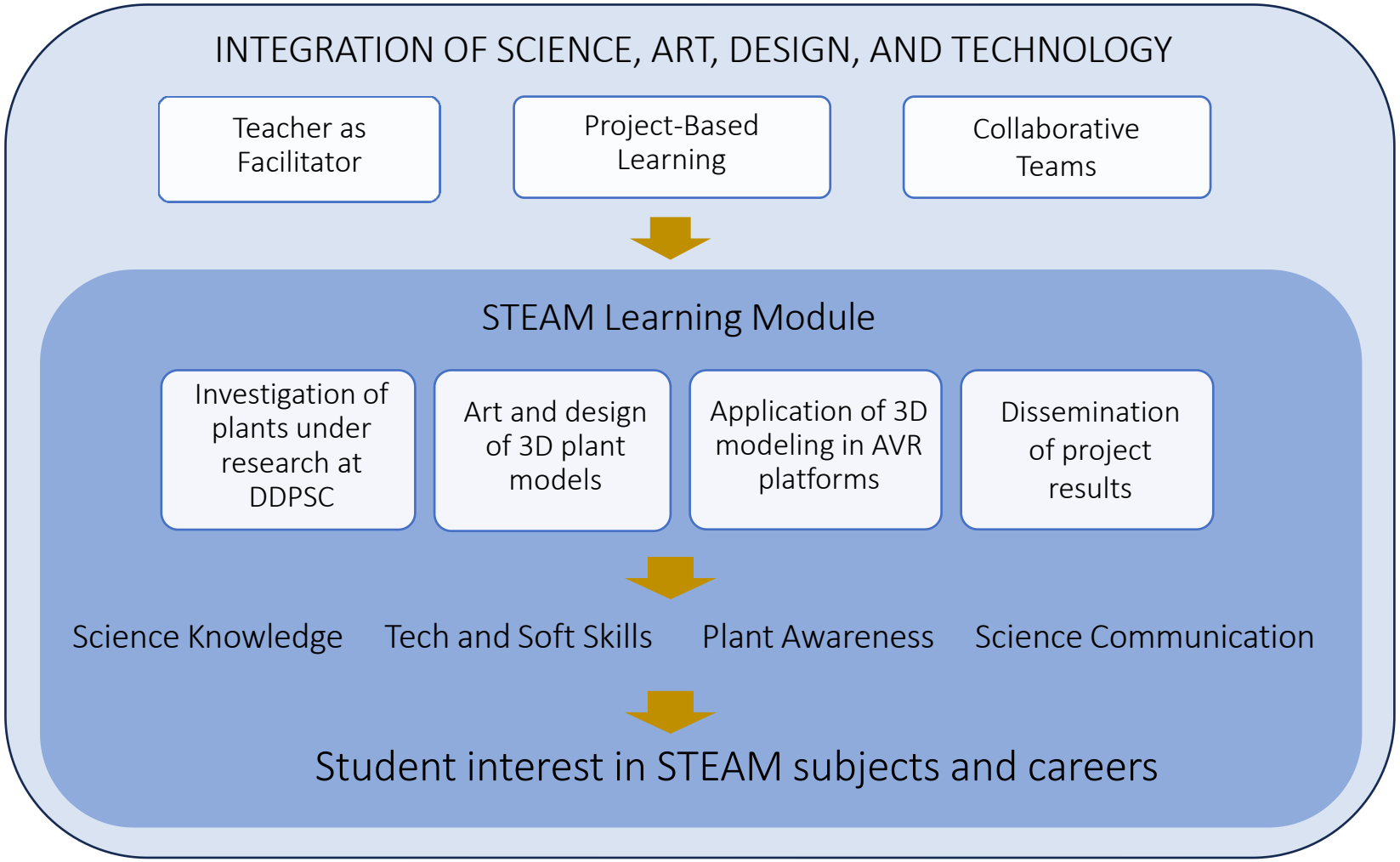
Pedagogical strategies

Interactivity

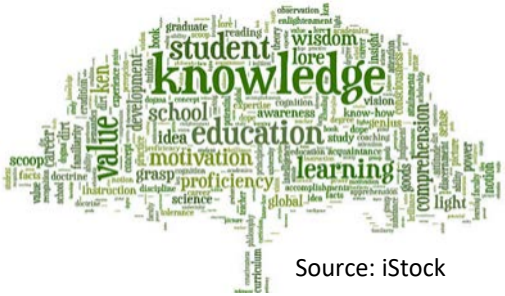
Interdisciplinary subjects of STEAM

Lin & Tsai, 2021

SADT Approach



Research Questions



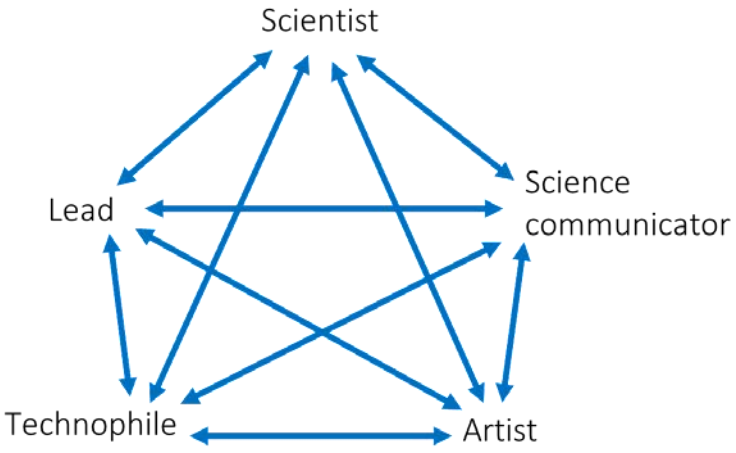
Source: iStock

What are the students' learning and skills gains from using the SADT approach?

What is the impact of the SADT approach on students' interest in STEAM subjects and careers?

Collaboration

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

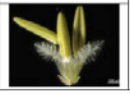


+

Support:

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

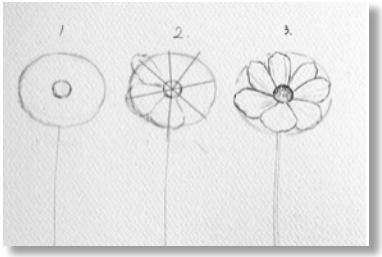
Investigation of plant species under research at DDPSC

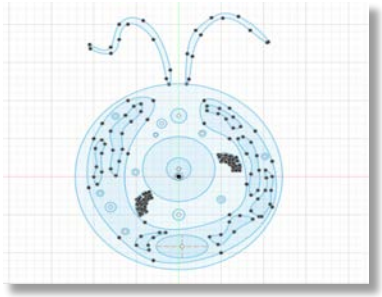
Wheat ***(Triticum aestivum)***	Flower		**Scientific advisors:** Dr. Blake Meyers (BMeyers@danforthcenter.org) Ryan DelPercio (RDelPercio@danforthcenter.org) Sebastien Belanger (SBelanger@danforthcenter.org) Lab website **Research Program:** To enable the hybridization of entirely new crops by understanding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

- Plant biology: life form, habitat, distribution, reproduction
- Importance: e.g., fix nitrogen, crop, climate adaptation
- Danforth research: e.g., seed dispersal, model plant

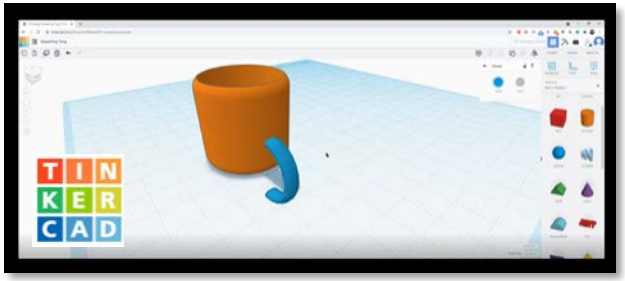
Art and Design of 3D models

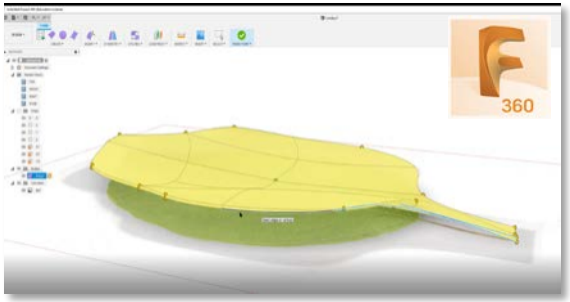
The concept art



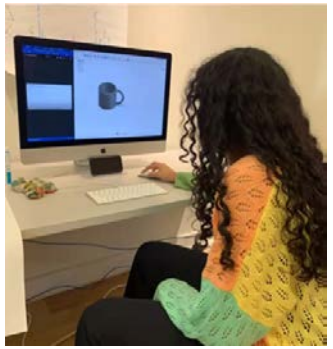


3D modeling self-training





3D model creation



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Applications of 3D models in AVR

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Augmented Reality (AR)

oculus

Virtual Reality (AR)

Dissemination of Project Results

Posters

One-page handout

Websites

Digital presentations

Mix-Methods Approach

Qualitative

Pre/Post Reflection questions about the STEAM learning and skills gains, outcomes, and interest in STEAM careers. (Deductive coding)

Quantitative

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

IRB approval
Parent consent
Student assent

On-line surveys - Qualtrics

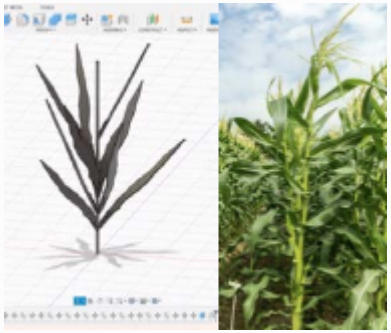
Educational Institutions (Summer 2020 – Spring 2023)

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

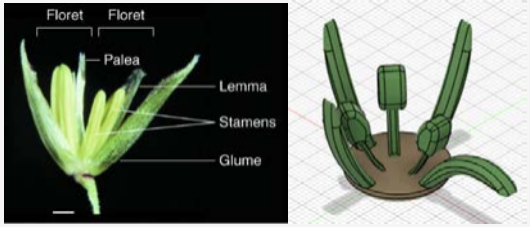
3D Plant Models

Common milkweed (*Asclepias syriaca*)

Chlamydomona (*Chlamydomonas reinhardtii)*

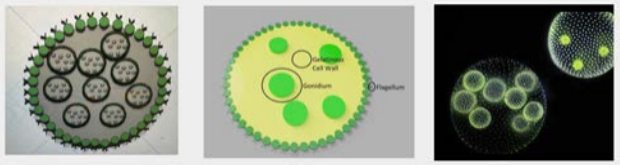


Corn (*Zea mays*)



Corn male floret (*Zea mays*)

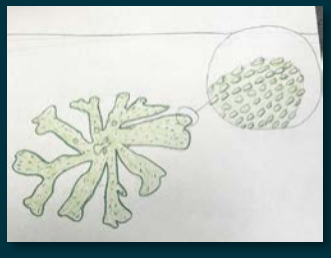
Corn female floret/pollination tube (*Zea mays*)



Green algae volvox (*Volvox carteri*)

Indiangrass spikelet (*Sorghastrum nutans*)

Big bluestem grass spikelet *(Andropogon gerardii)*

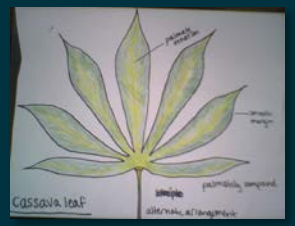


What are the students' learning and skills gains from using the SADT approach?

Themes	No. students with only pre responses		No. students with pre and post responses		No. students with only post responses		Total No. students per theme	
	No.	%	No.	%	No.	%	No.	%
Learning new/interesting things	11	17.5					11	17.5
Learning about science	5	7.9			5	7.9	10	15.9
Learning about plants	7	11.1	6	9.5	25	39.7	38	60.3
Learning about research skills	3	4.8			13	20.6	16	25.4
Learning about 3D modeling	15	23.8	9	14.3	11	17.5	35	55.5
Learning about design/art	8	12.7	1	1.6	7	11.1	16	25.4
Learning soft skills								
Learning about communication	1	1.6			7	11.1	8	12.7
Learning about science communication			1	1.6	4	6.3	5	8.0
Learning about teamwork/collaboration					17	27.0	17	27.0
Learning about perseverance					3	4.8	3	4.8
Learning about time management and memory					6	9.5	6	9.5

Percentages are calculated with respect to a total of 63 students participating in the pre and post reflection questions (100%). Percentages per column or row do not add to one hundred since some students provided responses for more than one theme.

Pre/Post responses: 63 students



Changes in interests in STEAM subjects and careers

Paired t-test comparisons between pre and post responses to the STEAM Semantics survey

Subject	Pre-survey mean (SD)	Post-survey mean (SD)*	t- value	P value
Science	2.8 (1.5)	2.6 (1.4)	3.7	**0.000**
Technology	2.9 (1.7)	2.8 (1.5)	1.3	0.2
Engineering	3.2 (1.6)	3.2 (1.5)	0.3	0.8
Mathematics	4.2 (1.8)	4.0 (1.8)	2.6	**0.008**
Design	2.9 (1.7)	2.5 (1.3)	4.1	**0.001**
Careers in STEAM	2.8 (1.6)	2.8 (1.5)	1.0	0.3

* The smaller the mean values, the more positive the responses are. Students responded on a Likert scale of 1-7, with 1 being the most positive choice and 7 being the most negative choice for each of the five statements per subject. SD – Standard Deviation. Significant p-values equal ≤ 0.05.

77 students, 385 responses per subject

Changes in interests in STEAM subjects and careers

Responses to the post reflection question:

"Has participating in this project changed your interest in science and or art/design careers moving forward? If so, how?

Themes	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
Unknown reason	24	35.3
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.

Conclusions

What are the students' learning and skills gains from using the SADT approach?

- Learning about science, plant science, 3D modeling, and art/design
- Gaining new skills: teamwork, communication, perseverance, time management, and memory

Conclusions

What is the impact of the SADT approach on students' interest in STEAM subjects and careers?

- Students showed a significant increase in interests in science, mathematics and design
- Students expressed more interests in science and STEM careers
- Many were already interested in STEM careers

What is next?

- Finish analyzing rural data from Spring 2024
- Examine student differences in learning and skills gain among institutions (urban vs rural, public vs private, etc.)
- Examine student outcomes related to productive failure, team dynamics, and science communication.

Acknowledgements

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Ladue Horton Watkins High School
Lafayette High school
Lindbergh High School
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Parkway West High School
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