

Work-In-Progress: Faculty and Student Perceptions of the Integration of Arts-Related Material into Engineering Courses and Curricula

Ms. Shawna Dory, Pennsylvania State University

Shawna Dory is a PhD candidate in the Education Policy Studies Department at Pennsylvania State University. She has a bachelor of arts degree in Sociology from Geneva College, and earned a master's of education degree in Counselor Education, Student Affairs from Clemson University. Along with her role as a PhD candidate, she is also a research assistant in the Leonhard Center for Enhancement of Engineering Education at Penn State. Her research interests include gender equity and women student persistence in engineering education, and first-generation student persistence in engineering education. Shawna has also done work related to sexual misconduct and Title IX implementation in higher education.

Dr. Sarah E. Zappe, Pennsylvania State University

Dr. Sarah Zappe is Director of the Leonhard Center for the Enhancement of Engineering Education and Assistant Dean of Teaching and Learning at Penn State. She holds a doctoral degree in educational psychology emphasizing applied measurement.

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This mixed-methods Work-In-Progress (WIP) paper is designed to capture engineering faculty and students' perceptions of the integration of the arts and engineering into engineering courses and curricula. There is a lack of prior investigation into the subject of faculty and student perception and curriculum development concerning the integration of the arts and engineering. This study intends to create a baseline understanding of how engineering faculty and students perceive the integration of the arts and engineering and measure the interest around courses and curriculum development concerning the arts and engineering.

Literature Review

The integration of arts into STEM education has been fairly common in the K-12 setting, with STEAM (Science, Technology, Engineering, Arts, and Math) initiatives continuing to proliferate in schools nationally and internationally [1], [2], [3]. The integration of the arts and engineering in the higher education context has been more limited. However, in recent years, universities have started to explore how the arts could be integrated into engineering through various initiatives [4], [5]. Some other examples include co-curricular events (i.e., the Annual Art/Engineering Project Showcase at the University of Florida), endowed institutes (i.e., the Krenicki Arts and Engineering Institute at the University of Connecticut), and interdisciplinary degree programs (i.e., the Intercollege Degree in Colleges of Engineering and Fine Arts at Carnegie Mellon University). Another example of integrating the arts with STEM in higher education includes a study examining the ArtsScience program at two-universities, which found that the experiential learning helped increase retention in their programs [6]. Another study shared a rationale for STEAM developed from a systematic literature on STEAM (science, technology, engineering, arts, and math) in higher education [7]. The three-prong rationale includes 1- STEAM for inclusion in STEM education, 2- STEAM for 21st century skills development, 3- STEAM for Transdisciplinarity where discipline [7]. Integration of the arts into engineering higher education has much potential.

In the engineering workforce, new opportunities are emerging that require interdisciplinary expertise in technical disciplines, the social sciences, and art. One frequent example is in theatre design and production [8], [9], [10], [11]. Technological advances such as 3D printing of materials like glass or concrete have uses in design, construction, and manufacturing, but can also be utilized to create beautiful works of art [12], [13]. All of these experiences require artists to work closely with engineers and technicians. Additionally, new digital technologies such as NFT (nonfungible tokens) art forms and artificial intelligence generators merge technology with art which may have interesting, and perhaps concerning, economic and educational consequences [14]. All of these areas are ripe for exploration in engineering education and can be best understood by partnership with engineers, artists, and social scientists to learn new discourse, approaches, and ways of thinking. This paper intends to gather the perceptions of College of Engineering (COE) faculty members and students related to the integration of the arts and engineering, as well as document how faculty and are currently merging the arts and engineering in their teaching and research.

Research questions

This exploratory, work-in-progress study explores two sets of research questions relating to students and faculty in a large, research intensive (R1) College of Engineering (COE) located in the mid-Atlantic states. These questions follow: 1) What are faculty members' perceptions of arts/engineering integration? How have the arts been previously integrated into courses/curriculum? What is the level of interest in this integration? How does it vary by faculty demographics? 2) What are students' perceptions of arts/engineering integration? Have they had art/engineering integration experiences within their engineering courses? What is the level of interest in this integration? How does it vary by student demographics?

Methods

The study utilizes a mixed-methods approach, combining results from quantitative survey data with coded results of open-ended survey questions. The faculty and student surveys were administered online using Qualtrics to both COE faculty and students. Faculty and students were invited to participate via emails and flyers. Two similar, but separate surveys were used for the two populations. Faculty survey questions included gathering information on how COE faculty integrate the arts into their teaching and research, how much they think the arts and engineering impact one another (if at all), and what initiatives they would like to see the COE initiate in support of the integration of engineering and the arts. Survey questions are featured in Appendix A. The project was started solely in COE before including faculty from the college of arts and architecture. Quantitative survey data has been analyzed using descriptive statistics. The qualitative data was coded based on themes that emerged from the reported responses. This paper focuses on the faculty results, as the student data was collected later and has not been examined yet. We do not yet have a theory to guide work as we wanted to do an exploratory study just to examine interest. However, for future work, we are examining Astin's IEO model [15].

The student survey gathered responses explaining students' levels of interest in integrating engineering and the arts, if and how often they can identify examples of integrating the arts and engineering have been utilized in their course instruction/coursework, their level of agreement that the arts and engineering impact one another, and their level of interest in curricular and co-curricular initiatives focused on the integration of engineering and the arts. The student data collection culminated at the end of the Fall 2023 semester; thus, no preliminary results for this survey are currently available.

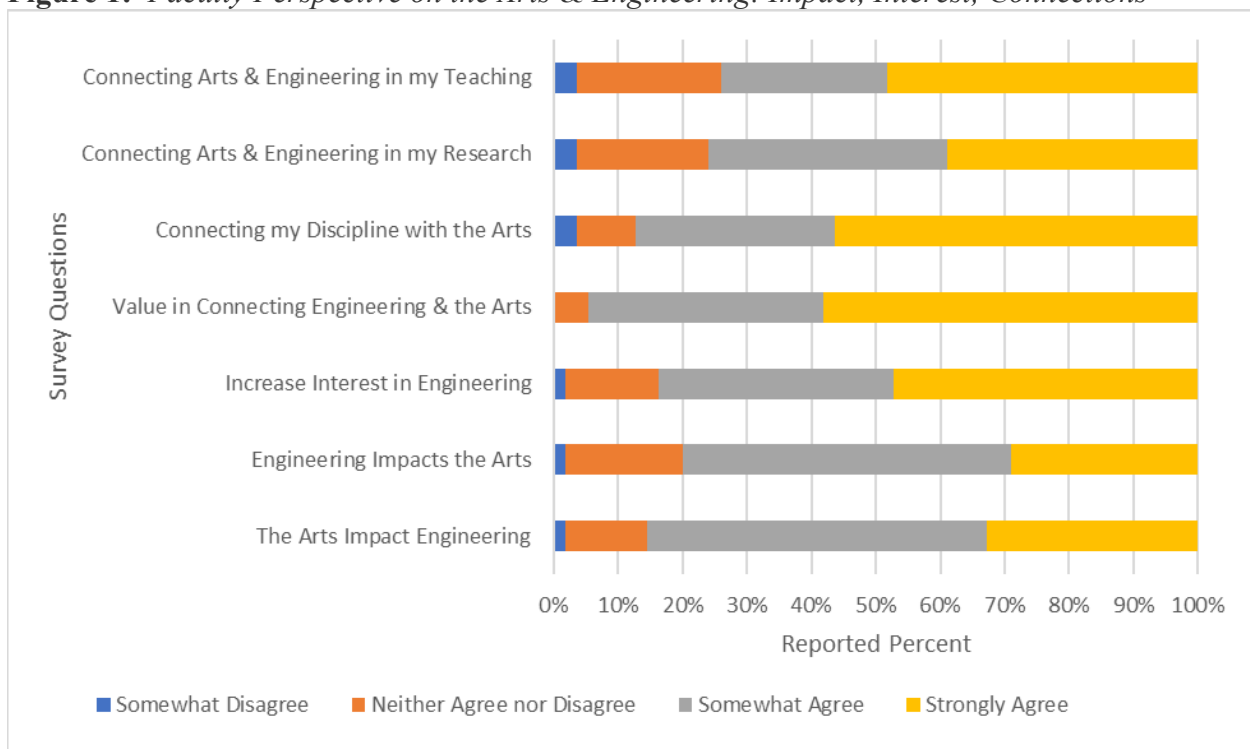
Preliminary Results

Initial findings have shown that faculty have strong preferences for professional development, seed grants, and workshops sponsored by the COE on how they can better integrate the arts into their teaching and research. Results have also shown that COE faculty are interested in more collaborations with College of Arts & Architecture faculty, including the creation of new arts courses for engineering students, and adding arts components into existing courses. A total of 65 faculty respondents from over 14 departments were represented. Gender breakdown of faculty respondents included 60% identifying as men, 36.4% as women, and 3.6% preferred not to report their gender identity. Position breakdowns included 74.0% reported being assistant professors, associate professors, professors of practice, or professors; 3.6% reported having the position of assistant research professor or researcher; 18.2% reported holding the position of instructor,

assistant teaching professor, associate teaching professor, or teaching professor; and 3.6% reported holding the position of administrator (dean, associate dean, assistant dean, department head).

One set of questions used a 4-point Likert scale response option, and further explored faculty perspective on the arts and engineering. A high majority (85.4%) somewhat or strongly agreed that the arts impact engineering. A total of 80.0% somewhat or strongly agreed that engineering impacts the arts. A majority (83.7%) agreed that connecting engineering to the arts would help to increase interest in engineering. Almost all (94.6%) agreed that they see the value of connecting engineering with the arts. A majority (87.3%) agreed that they see the value of connecting their discipline with the arts. A total of 75.9% agreed that they are interested in connecting arts and engineering in their research, while 74.0% agreed that they are interested in connecting arts and engineering in their teaching. The bar chart below (Figure 1) compares these results by question.

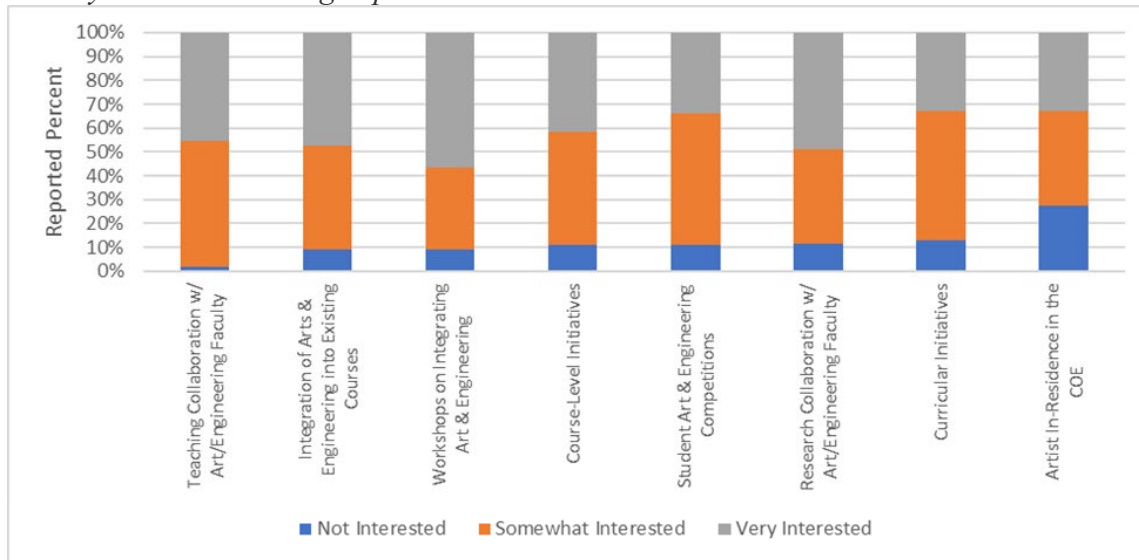
Figure 1: *Faculty Perspective on the Arts & Engineering: Impact, Interest, Connections*



The next set of questions was asked on a 3-point scale (not interested/somewhat interested/very interested) about whether faculty would be interested in having the College pursue each initiative. Figure 2, below, shows the overall faculty interest of different proposed initiatives in descending order. The responses of very interested and somewhat interested were totaled to determine the order of interest. When totals were equal, they were placed in alphabetical order. Overall, faculty were interested in each of the initiatives proposed in the questions. The initiative with the most interest garnered, with almost all faculty (98.2%) being interested, was a teaching collaboration with art/engineering faculty. The second most was shared between two initiatives. 90.9% of faculty were interested in workshops on how to integrate art into engineering, and 90.9% of faculty were somewhat or very interested in the integration of arts into existing engineering courses (or integration of engineering into specific art courses). The third most interest in initiatives was also

shared. 89.1% of faculty reported being very or somewhat interested in the college pursuing course-level initiatives relating to the arts in engineering, and 89.1% were “somewhat interested” to “very interested” in having student art competitions with engineering themes. A total of 88.7% were interested in a research collaboration with art/engineering faculty. A similar number (87.2%) of respondents were also interested in curricular initiatives relating to the arts in engineering. Slightly fewer faculty, 72.7%, were interested in an artist-in-resident in the College of Engineering.

Figure 2
Faculty Interest in College Sponsored Initiatives



The qualitative, open-ended questions findings showed similar results. Table 3, below, represents the codes procured and example quotes from the survey question “Describe how you connect the arts with engineering in your teaching.” Faculty reported an array of examples of how they connect the arts with engineering in their teaching, as detailed below. Some of the themes found for how faculty connect the arts with engineering in their teaching included writing, design, imagination and creativity, connecting “real world” examples to art & engineering, architecture, and visual media.

Table 3: Codes & Example Quotes from question “Describe how you Connect the Arts with Engineering in your Teaching”

Code	Example Quotes
Writing	<i>“When I’m having students write, even their technical research papers, we always talk about the story of the paper and telling the story, which is inherently creative and artistic.”</i>
Design	<i>“Designing solutions that people want to use and incorporate into their life to add beauty as well as function.”</i>
Imagination & Creativity	<i>“[When a previously program I worked on was in operation, a] student built an interactive audio-kinetic tensegrity sculpture that they studied as a structural dynamical system for their thesis, and also used it for their final project in a performance art class that they took in parallel.”</i> <i>“I occasionally mention artworks, like kinetic sculptures and systems, that illustrate certain system behaviors.”</i>

Real World Art & Engineering Connection	<p><i>"I have spoken about fractal structures, and mathematics of complex surfaces in my classes."</i></p> <p><i>"When teaching sound waves, I have cited examples of ancient monuments such as whispering halls that were based on sound engineering or citing a spinning ballerina while introducing circular motion."</i></p> <p><i>"When teaching students about culturing bacteria on solid media, I show them examples from the American Society for Microbiology's annual agar art competition, which has absolutely amazing examples of art generated with microbes on agar plates."</i></p>
Architecture	<p><i>"Architectural elements often pose both opportunities and challenges with engineered systems. Examples used include elements where exterior building shafts had to be added to a retrofit project to create space for engineering environmental systems, but the architect was creative in translating these into architectural features rather than trying to hide them."</i></p>
Present Visual Photographs / Videos	<p><i>"When describing a difficult problem (where we did the calculations by hand), I also include graphics that use these calculations (from computer games or 3D animation). I also try to incorporate where we see things in nature (esp. for physics and sometimes math)."</i></p>
Subject Matter viewed as Art	<p><i>"It's fun to look at the spatial spectral densities of a Pollock (Jackson Pollock painting). Ties into electrical engineering nicely."</i></p>

Discussion & Next Steps

Results showed that faculty overall would like additional opportunities to collaborate with faculty members in the College of Arts & Architecture, that they believe the integration of art and engineering in their teaching is important, and some even have existing innovative structures for integrating the arts into their course curriculums. There are several next steps for this project. One major next step will be to finalize faculty data analysis and analyze the student data once the student survey is closed. Once we have the student results, we will draw on similarities and differences in response type from the different populations. We are also exploring a theoretical framework to guide future work, such as Astin's IEO model.

Overall, the integration of art into engineering has some interesting possibilities. While this work-in-progress paper was exploratory, we would like to build a research agenda in this area. Finding a suitable theoretical framework for why art/engineering integration is important is one of the first steps. A second step is conducting a systematic literature review in this area. We hypothesize that integrating the arts into engineering may help to build interest in engineering for a diverse set of students. We have started to build faculty development offerings in this area, such as an art/engineering learning community and funding art/engineering integration projects that could impact the curriculum.

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Appendix A. – Faculty Survey Questions

Q1 What is your primary departmental affiliation?

- Acoustics (1)
- Agricultural and biological engineering (2)
- Aerospace engineering (3)
- Architectural engineering (4)
- Biomedical engineering (5)
- Chemical engineering (6)
- Civil engineering (7)
- Electrical engineering and computer science (8)
- Engineering design and innovation (9)
- Engineering science and mechanics (10)
- Industrial and manufacturing engineering (11)
- Mechanical engineering (12)
- Nuclear engineering (13)
- Other (please list) (14) _____

Q2 How familiar are you with examples of how the arts and engineering may intersect or connect?

- Very familiar (4)
- Familiar (3)
- Somewhat familiar (2)
- Unfamiliar (1)

Q3 When you think of the arts, what links to engineering come to mind? In other words, what examples can you think of that engineering and the arts connect?

Q4 Have you ever collaborated with another faculty member from the College of Arts and Architecture (or similar college at another university)?

- Yes (1)
- No (2)

Q4.1 Please briefly describe the collaboration between you and a faculty member from the College of Arts and Architecture (or similar college at another university)?

Q5 Have you ever collaborated with a company/business on a project that involved the arts?

- Yes (1)
- No (2)

Q6 Please briefly describe the collaboration between you and a company/business on a project that involved the arts.

Q7 In your **teaching**, do you ever make connection between the arts and engineering (for example, demonstrate how a concept relates to something from the arts)?

- Yes (1)
- No (2)

Q8 Describe how you connect the arts with engineering in your **teaching**.

Q9 In your **research**, do you ever make connections between the arts and engineering?

- Yes (1)
- No (2)

Q10 Describe how you connect the arts with engineering in your **research**.

Q11 Do you play or have you ever played a musical instrument?

- Yes (list which instruments) (1) _____
- No (2)

Q12 Do you have (or ever had) any hobby involving the visual arts (i.e., painting, sculpture, etc.)?

- Yes (list your hobby) (1) _____
- No (2)

Q13 Other than what may be listed above, what other arts-related hobbies do you currently have?

Q14 What non-arts related hobbies do you currently have?

Q15 Please rate how much you agree with the following statements:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
The arts impact engineering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Engineering impacts the arts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Connecting engineering to the arts would help increase interest in engineering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I see the value of connecting engineering with the arts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I see the value of connecting my discipline with the arts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am interested in connecting arts and engineering in my RESEARCH	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I am
interested in
connecting
arts and
engineering
in my
TEACHING

Q16 What opportunities, if any, should the College of Engineering offer to students regarding the connection between the arts and engineering?

Q17 What kinds of opportunities, if any, should the College of Engineering offer to faculty regarding the connection between the arts and engineering?

Q18 Rate the following items in terms of whether you would be interested in having the College pursue each:

	Not interested (1)	Somewhat interested (2)	Very interested (3)
a. Student art competitions with engineering themes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Curricular initiatives relating to the arts in engineering (i.e., a minor or program)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Course-level initiatives relating to the arts in engineering (i.e., a specific course)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Integration of arts into existing engineering courses (or integration of engineering into specific art courses)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Research collaboration with [art/engineering] faculty	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Teaching collaboration with [art/engineering] faculty	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Artist-in-resident in the College of Engineering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- | | | | |
|---|-----------------------|-----------------------|-----------------------|
| h. Workshops on how to integrate art into engineering | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. Other (please list) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Q19 What gender do you identify as?

- Man (1)
- Woman (2)
- Transgender (3)
- Non-binary or non-conforming (4)
- Prefer not to respond (5)

Q20 Is your ethnicity Hispanic/Latino (Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin)?

- Yes (1)
- No (2)

Q21 What is Your Race? (check all that apply)

- American Indian or Alaskan Native (1)
- Asian (2)
- Black or African American (3)
- Native Hawaiian or other Pacific Islander (4)
- White (5)

Q22 What is your position type (check all that apply)?

- Assistant Professor (1)
- Associate Professor (2)
- Professor (3)
- Assistant Research Professor (4)
- Associate Research Professor (5)
- Research Professor (6)
- Assistant Teaching Professor (7)
- Associate Teaching Professor (8)
- Teaching Professor (9)
- Instructor (10)
- Researcher (11)
- Professor of Practice (12)
- Administrator (Dean, Associate Dean, Assistant Dean, department head) (13)
- Other (list) (14) _____

Q23 Please add any additional comments you may have that you feel we should know related to the topic of this survey (the connection between the arts and engineering).
