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3D Shakespeare: A Transdisciplinary Activity to Enhance Real-World Learning Experience in Engineering and Humanities Education

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Session XXXX

3D Shakespeare: A Transdisciplinary Activity to Enhance Real-World Learning Experience in Engineering and Humanities Education

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Abstract

This paper explores an innovative cross-disciplinary project conducted at the University of Texas at San Antonio, which integrated students from Engineering core class "Introduction to Materials Science and Engineering" and English core class "Shakespeare: The Later Plays" into a collaborative learning experience. The project aimed to bridge the gap between classroom knowledge and real-world application by pairing Engineering and English students to design and learn 3D printing to fabricate stage props and models based on Shakespearean plays. This hands-on project required students to transcend their disciplinary boundaries and engage in a real-world "designer/client – technical provider" interaction. This paper evaluates the impact of this transdisciplinary project on student learning, utilizing a combination of project reports, presentations, and a student survey followed by content analysis. Results indicate significant benefits in terms of students' exposure to new technologies notably 3D printing, improved interdisciplinary communication, and the practical application of classroom knowledge. Challenges such as effective communication within diverse teams and mastering technical tools are identified; future improvements are discussed. This study demonstrates the potential of cross-disciplinary projects in enhancing student learning by emphasizing the significance and relevance of class materials to topics outside students' immediate fields, and providing practical, collaborative experiences that prepare students for real-world challenges.

Introduction

A critical goal in higher education is to teach students how to effectively employ knowledge and skills acquired in the classroom within a practical, real-world context. It is also imperative for students to transcend conventional disciplinary boundaries and collaborate with those who have different educational backgrounds. As educational pedagogy has suggested, experimental and interdisciplinary learning should result in greater student learning.[1-3] Therefore, transdisciplinary activities embedded in regular courses could provide context outside the classroom and bridge the gap between knowledge learned in the classroom and real-world applications for students.

In this paper, we present the conceptualization and initial evaluation of a highly innovative cross-disciplinary experiential learning activity. A collaborative class project was created and integrated into two different core courses at the University of Texas at San Antonio (UTSA), “Introduction to Materials Science and Engineering” for Chemical and Biomedical Engineering students, and “Shakespeare: The Later Plays” for English majors. Engineering and English students were paired in groups for this project and given a hands-on task that required both engineering and English knowledge and skills. English students were asked to provide an illustrative design of a scene or an object based on the text of a key scene in a Shakespearean play; Engineering students were tasked with generating a 3D model from the illustrative design and fabricating it in the UTSA Makerspace. The English students then used the 3D model as a stage prop to perform a creative skit (stage play, film, or podcast) by adapting the original Shakespeare play.

Cross-disciplinary learning activities between STEM majors and Humanities majors have recently been explored to broaden students’ experiences and enhance learning outcomes. Nickel *et al.* reported an interdisciplinary learning activity between elective courses from different departments: Nanoscience and Nanotechnology, a science elective, and Science Fiction, a general studies elective.[4,5] In Nickel *et al.*’s study, students from both classes were involved in discussions on topics around a common theme to understand the societal impacts of new technologies. However, such cross-disciplinary learning activities typically require the classes to share a common theme to engage students, which makes it challenging to design activities beyond classroom discussions and integrate them into core courses.

The project presented in this paper aims to create a hands-on experience by simulating a real-world "designer/client – technical provider interaction". Instead of finding a common theme for both classes, we sought to simulate this real-world interaction, enhancing learning in both disciplines. Although the two courses have completely different scopes, themes, and training goals, this activity encourages collaboration between students with different educational backgrounds to complete tasks that require the integration of diverse skill sets. We challenged both Engineering and Humanities students to apply their training and knowledge in real-world scenarios. This unique learning activity serves the dual purpose of preparing engineering students for real-world challenges in their field and inspiring humanities students to apply their literary and artistic expertise in the design and creation of finished products.

We conducted a survey study after the completion of this project and used content analysis to identify key advantages of this interdisciplinary learning activity. Our results show that when students from entirely different academic backgrounds (Engineering vs. Literature) collaborated, they gained a deeper understanding of their respective course materials, as they had to teach their subjects to an audience with no prior knowledge. This interaction also significantly improved the professional communication skills of both Engineering and Humanities students. Furthermore, students learned how to apply their classroom materials (Materials processes for Engineering students and Shakespeare in the modern world for English students) in industry and society by delving into topics beyond their classes and making compromises and adjustments in this real-world "designer/client – technical provider" interaction experience. The challenges and potential future improvements of this experimental transdisciplinary learning activity are also discussed in this paper.

Methods

Project Design

This project was a collaboration between students from two classes in the Fall 2024 semester at UTSA: "Introduction to Materials Science and Engineering" for junior students in Chemical and Biomedical Engineering, and "Shakespeare: The Later Plays" for senior students majoring in English. Engineering students were randomly assigned to teams, each comprising 6 or 7 students from both Chemical and Biomedical Engineering. Each Engineering team was paired with a team of English students. The English team was tasked with providing an illustrative design of a scene or an object based on the text of a key scene in a Shakespearean play, acting as a client for the Engineering team. The Engineering team was charged with generating a 3D model from the illustrative design, identifying an appropriate 3D printing manufacturing technique, fabricating the 3D model in the UTSA Makerspace, and eventually returning the final product to the English team. The project had a 1-month deadline to simulate real-world time constraints. To successfully complete the project, Engineering students needed to understand the design requirements by communicating with the English students, learn 3D printing modeling and manufacturing techniques, and execute the manufacturing process by iterating with the Makerspace 3D printing lab. At the end of the project, a joint presentation was held between the two classes, with Engineering teams analyzing the technical process of fabricating the 3D model and English students using the 3D model as a stage prop to perform a creative skit adapted from the original Shakespeare play.

Data Collection

Two groups of data were collected to analyze the students' performance and the effectiveness of this project in enhancing student learning. First, student performance was documented through project reports and presentations by each Engineering team. A technical overview of 3D printing techniques was assigned during the project to assess students' understanding of 3D printing through self-learning and hands-on experience. A final report and presentation were required to evaluate each team's ability to translate a non-technical illustrative design into 3D modeling and realization using appropriate 3D printing techniques. To evaluate the students' learning, the value of this project, and the challenges faced by students, a survey was conducted at the conclusion of the project. This survey included multiple-choice and open-ended questions, as summarized in Table 1.

Table 1. Project evaluation survey questions

Q1 (multiple choice)	How long did you spend on this project in total? a. Less than 10 hours b. 10-20 hours c. 20-30 hours d. 30-40 hours e. More than 40 hours
Q2 (multiple choice)	How effective do you feel this project helps you learn material processing technologies (i.e. 3D printing)? a. Very effective b. Somewhat effective c. Neutral d. Not as effective as traditional lectures

Q3 (open-ended question)	What do you learn the most from this project that is unique? What do you enjoy?
Q4 (open-ended question)	What is the most challenging part of this project for you?

Results and Discussion

To understand how this transdisciplinary project helps students learn and apply knowledge critical to their development, we evaluated student performance at the conclusion of the project and assessed their learning through survey responses. While both Engineering and English students uniquely benefited from this project, this paper focuses on the results from Engineering students in the "Introduction to Materials Science and Engineering" class, leaving the results from the English Shakespeare class for future discussions.

Student Performance

There were 10 groups in our joint class project, each consisting of an Engineering team (6-7 students) and an English team (2-6 students). After being paired into teams, Engineering and English students began communicating immediately and quickly decided on the topic for their 3D model. The topics included scenes and objects mainly from the late plays of Shakespeare, such as *Hamlet*, *Macbeth*, *King Lear*, and *Romeo and Juliet*. The initial illustrative 3D designs varied in size and detail between the different teams. Consequently, the Engineering teams were expected to learn and choose various 3D printing techniques to achieve their respective goals. The topics of the 10 teams are summarized in Table 2.

Table 2. Project topics from 10 teams

Team	Topic
1	"Three witches" scene from *Macbeth*
2	3D topographic map of the British Isles with symbols to represent the division of King Lear's land from *King Lear*
3	Bloody floating dagger from *Macbeth*
4	Hamlet's Castle from *Hamlet*
5	Lady Macbeth's hand tub with stand from *Macbeth*
6	Dagger from *Macbeth*
7	Hamlet's Goblet from *Hamlet*
8	Hamlet's poisoned Chalice from *Hamlet*
9	Macbeth's crown with hidden dagger from *Macbeth*
10	Juliet's potion bottle from *Romeo and Juliet*

For Engineering students, the primary goal of this project was to translate artistic design ideas from their non-technical "client" into a practical product by learning and using new material processing and manufacturing techniques (3D printing). We demonstrated the students' performance by asking them to show the progression of their project from the original artistic design by the English team, to the computer-aided 3D model they built, and finally to the completed product. All the Engineering teams were able to complete the 3D model based on the illustrative design provided by their English "client." For example, the model and project progression of three selected teams are shown in Figure

1. Team 1 and Team 9 created the 3D prints from simple hand sketches for either an imaginary scene (Team 1: "Three witches" scene from *Macbeth*) or a stage prop (Team 9: Macbeth's crown with hidden dagger from *Macbeth*). Team 4 recreated a real castle found in Germany to represent Hamlet's castle and successfully completed the large, yet detailed, print after two failed attempts. Through iterative communication with the English team, our students exhibited surprising creativity in their products by seamlessly merging manufacturing technology with artistic interpretations of canonical literature, despite the Engineering students having little knowledge about Shakespeare and the English students having limited understanding of 3D printing. All the Engineering teams participating in the project achieved the primary goal.

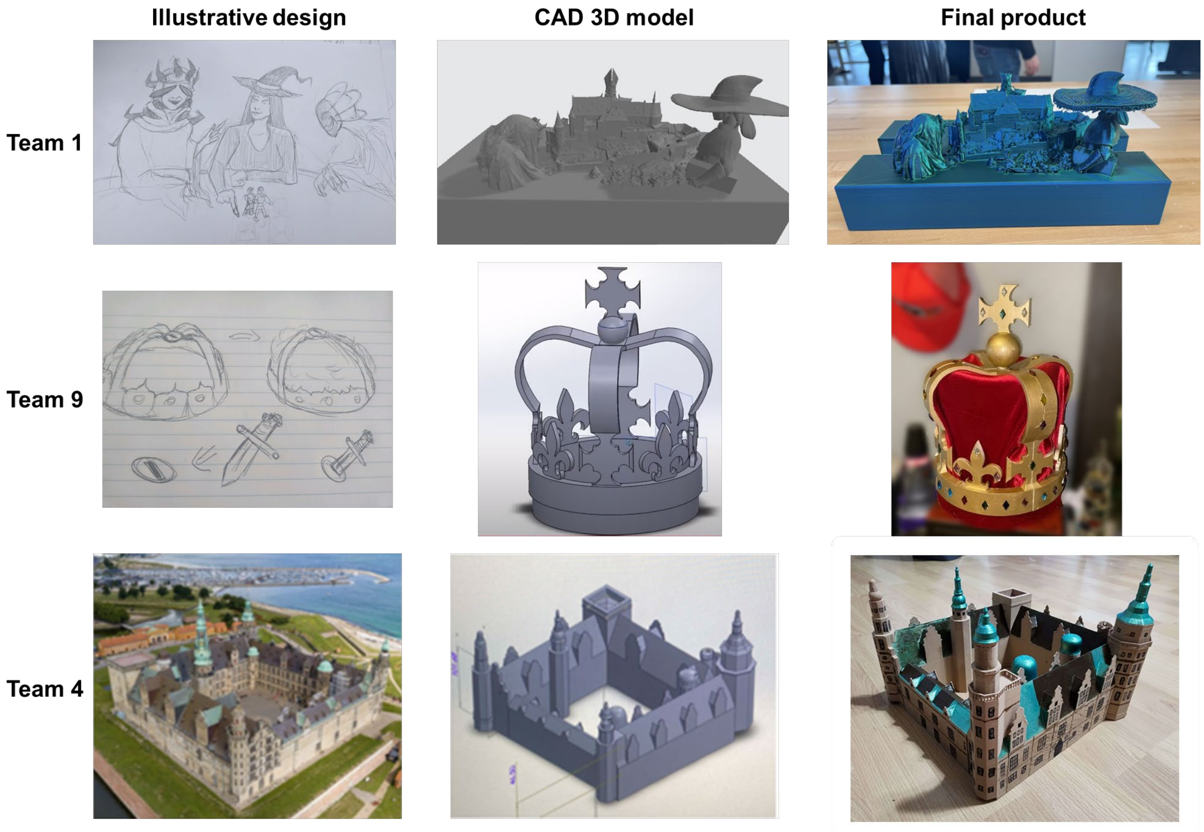

Figure 1. Project progression of three selected teams.

Evaluation of Student Learning

We further evaluated the unique advantages of this transdisciplinary project in helping students learn material processing technology, using a project survey (questions summarized in Table 1). A total of 62 students were enrolled in the "Introduction to Materials Science and Engineering" class, with 56 out of 62 students responding to the survey. To estimate the effort required for students to be successful in this collaboration, we asked how much time they spent on this project (Q1). Seventy percent of students spent 10 or more hours on this project, with more than one-third spending more than 20 hours (Figure 2). Considering that this project required various tasks, such as communication with the English team, 3D model design, and printing with Makerspace, all shared among 6-7 students in one Engineering team, we deemed 10 hours per individual to be a reasonable amount of time to ensure team success. The majority of students (70 percent) put in sufficient effort and gained valuable experience. Some students may not have been as active as others, as the project was scheduled close to the end of the semester, requiring students to balance it with other courses.

We then asked students whether they considered this project effective in helping them learn a new material processing technology (3D printing) compared to the traditional lecture approach. As shown in Figure 2, 93 percent of students believed that this project was more effective than the traditional approach, with 50 percent of students agreeing that this project was very effective. This is likely because the students gained hands-on experience by completing the project. More importantly, Engineering students were compelled to understand the technique better since they had to explain the modeling and manufacturing of the product to their English collaborators, who had no relevant knowledge about 3D printing or materials science and engineering in general.

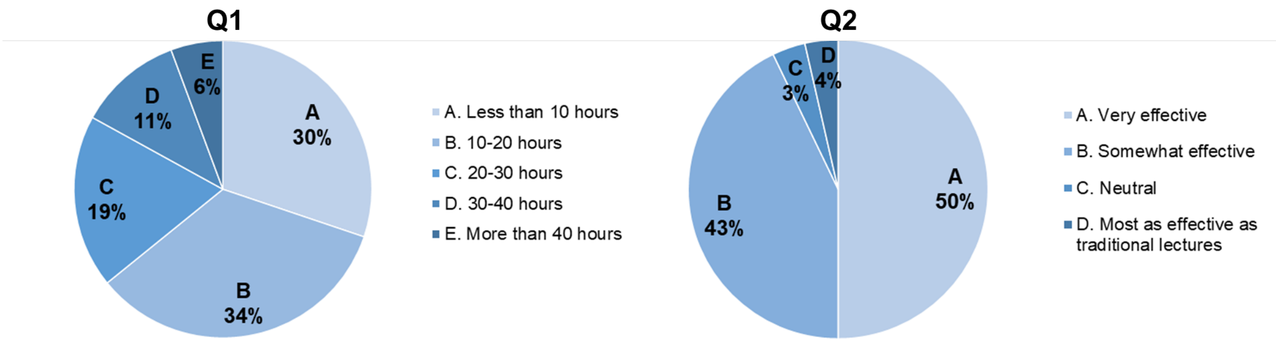

Figure 2. Multiple-choice survey question responses. Q1: How long did you spend on this project in total? Q2: How effective do you feel this project helps you learn material processing technologies (i.e. 3D printing)?

To understand students' perceptions of the unique value and challenges of this project, we conducted a content analysis of the 56 students' responses to two open-ended questions (Q3 and Q4), using an approach similar to that employed by Vieira *et al.*[6]. Q3 was designed to identify unique advantages, while Q4 aimed to understand the challenges faced by students. Analyzing students' responses to these questions allowed us to infer consensus and identify unique strengths and areas for improvement in this transdisciplinary approach to teaching Engineering science and technology. Table 3 describes the categories we identified as unique advantages and values of this project, and Table 4 outlines the categories for challenges identified from students' responses.

Table 3. Coding scheme employed to categorize the students' responses in Q3 to identify advantages and examples of student response in each category.

Question	Category Name	Code	Examples of student's response
Q3: What did you learn the most from	Exposure to new technology (3D printing)	VAL1	- *"I learned much more about 3D printing. Before I only had an idea of how it worked."* - *"I am very new to 3D printing, so this project really opened the door to this technology."*

this project that is unique? What did you enjoy?	Gain proficiency in engineering design tools	VAL2	- *"I learned how to adapt quickly to a new software in order to make our designs. I really enjoyed the challenge that came with creating something completely new in regard to prior knowledge."* - *"Learning SolidWorks was great and challenging. It was a lot of fun to experiment with the tools. I haven't had many classes that made me model."*
	Satisfaction from interdisciplinary collaboration and creative tasks	VAL3	- *"I really enjoyed the crossover between Shakespeare and engineering, as I am majoring in engineering, but I also love to read and I was in theater tech in high school."* - *"What I enjoyed the most was the fact that this is a very different project from what I am used to. We were able to be creative and I liked that."*
	Real-world applications and problem-solving skill	VAL4	- *"I enjoyed this project because it shows how engineering disciplines can work across different industries and communication with artists, English majors, etc."* - *"I think that most of my engineering classes thus far have lacked any kind of practical application, so it was fun to work with a team of engineering to create a product to fit the needs of a 'client'."*
	Exercise project management and teamwork	VAL5	- *"I learned that it is harder to communicate in a group different than engineers because both groups need to understand what the other groups wants done. I enjoyed working with the English class, this was my first project that was not an all-engineering group."* - *"Communication is key, deadlines come fast if not prepared and I enjoyed a lot how it deals with different departments to mimic real life."*
	Appreciation in classic literature via modern technology	VAL6	- *"I learned about the hamlet goblet and the significance of the design on it, specifically about saint peters cross which is upsides down. I enjoyed making our design come to life."* - *"What I learn most from the project is*

			that Shakespeare theme is still an ongoing theme that continues in today's society. I enjoyed talking to the English class."

Table 4. Coding scheme employed to categorize the students' responses in Q4 to identify challenges and examples of student response in each category.

Question	Category Name	Code	Examples of student's response
Q4: What was the most challenging part of the project for you?	Communication and coordination in a diverse team	CHA1	*- "The most challenging part was being able to communicate with the team members and have everyone share their opinion."* *- "Having good communication with both the design and engineering group."*
	Time management to meet deadlines	CHA2	*- "Time-management because of the holidays and short time frame given. Decision making, there was a lot of choices to make throughout the process that require quick responses."* *- "The time limit was the hardest part; we were barely finishing because of the back and forth."*
	Learning curve to master technical tools	CHA3	*- "The biggest challenge was learning the software that we used to create the design before actually manufacturing the model."* *- "The most challenging part is using solidworks for designing the model."*
	Translating creative ideas to technical designs	CHA4	*- "Designing a castle was way out of the scope of my typical use of SolidWorks."* *- "The most challenging part is creating the art, because it is a new "stuff" to use but very fun and enjoyable."*

Figure 3 shows the frequency of responses for Q3 and Q4. Six categories of unique advantages of this project were identified from the students' responses. The three major advantages include "Exposure to new technology (3D printing)" (Code: VAL1), "Satisfaction from interdisciplinary collaboration and creative tasks" (Code: VAL3), and "Gaining proficiency in engineering design tools" (Code: VAL2). More than 25 percent of students identified at least one of these categories as their most significant learning outcome. This result demonstrates that this transdisciplinary project can effectively expose Engineering students to new technologies related to their class materials, encourage them to gain practical skills, and find satisfaction in the non-engineering aspects of the project. Four categories of challenges were identified from the students' consensus. The two major challenges are "Communication and coordination in a diverse team" (Code: CHA1) and "Learning curve to master technical tools" (Code: CHA3), with more than 25 percent of students agreeing on each. These results inform instructors that more support is needed to help students navigate the communication process in an interdisciplinary team and that technical resources are necessary to better prepare students to master technical tools. These are the areas for improvement in the design of future projects.

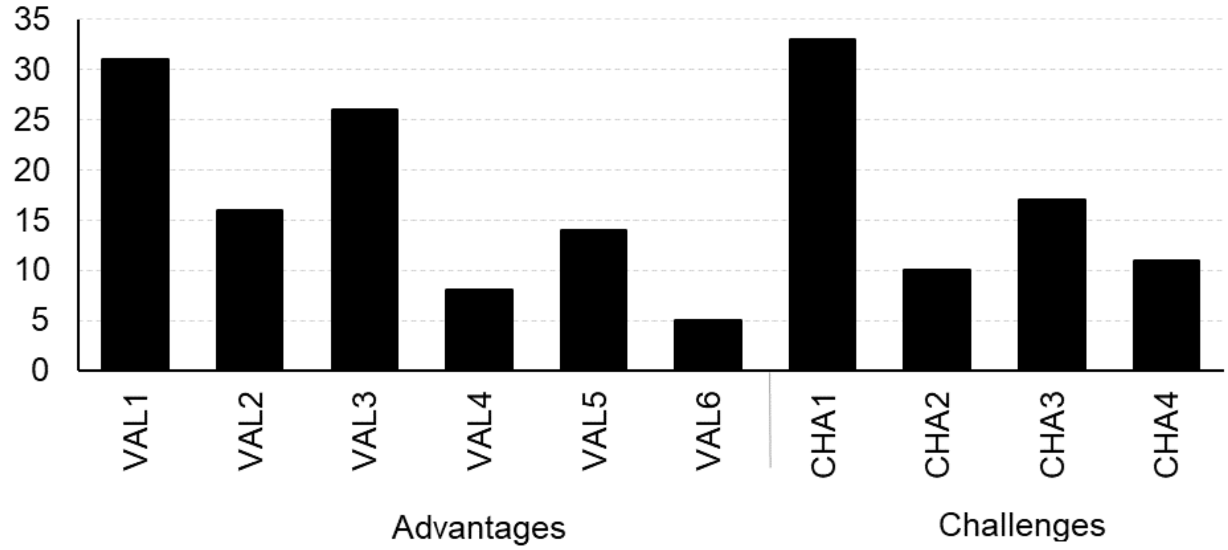

Figure 3. Frequency response of students' perceptions of the advantages and challenges of the 3D Shakespeare transdisciplinary collaborative project.

Summary and Conclusions

In summary, this paper presents an innovative cross-disciplinary project at the University of Texas at San Antonio, integrating Engineering and English literature courses to enhance experiential learning. Students from Engineering and English majors collaborated to design and fabricate 3D printed models based on Shakespearean plays, merging technical skills with creative interpretation. A survey was conducted to understand and enhance student learning, followed by content analysis. Our results indicate that by simulating a real-world "designer/client – technical provider interaction" scenario, this project demonstrates significant benefits for Engineering students, including exposure to new technologies, improved interdisciplinary communication skills, and the practical application of classroom knowledge. We have also identified challenges such as communication within diverse teams and mastering new technical tools, which could be addressed by adding additional training modules and resources in future projects. Overall, this initiative has proven successful in fostering a deeper understanding of both disciplines and highlighting the value of practical, collaborative learning in higher education.

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