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Culture-inspired creative design projects increase students' sense of belonging in freshman engineering design course

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Abstract

The impact of diversity on students' self-perceived improvement through multicultural curricula and classroom activities is not studied much. Accounting for social and cultural context is key to success in product design. Culture encompasses a set of shared assumptions and values, influencing ones behavior, attitudes, beliefs, norms, and aesthetics. This paper presents various interventions engaging authentic-self and culture inspired creative design project-based learning in freshman engineering design graphics course. Students are asked to incorporate the cultural / cross-cultural influence on creative home-décor products at the beginning stages of design through creative ideation, sketching, CAD and prototyping. The cultural / cross-cultural influence on the product is incorporated into the beginning stages of design using creative ideation methods included as part of the course interventions. Students enhanced engagement and sense-of-belonging in learning engineering graphics is assessed through pre and post-activity reflection and quality of design products.

Introduction and objectives

In addition to adjusting to new academic demands, many traditional freshmen students in the United States face being separated from their high school support groups and former way of life [1]. On the other hand, international freshman students with a low level of social integration can experience heightened anxiety and depression [2]. Social integration between international and domestic students can both enhance international students' well-being while concurrently benefitting domestic students' cultural awareness and respect for diversity [3]. When students feel like they belong in the classroom, they are more likely to be motivated to learn [4]. They feel invested in their education and are more likely to take ownership of their learning. The sense of belonging plays a crucial role in teaching and learning, as it is a fundamental aspect of creating a positive and supportive learning environment. When students feel a sense of belonging in the classroom, they are more likely to engage in the learning process, take risks in applying the discipline knowledge, and develop positive relationships with their peers and instructors. A strong

sense of belonging can contribute to an individual's overall well-being, self-esteem, and happiness, while a lack of belonging can lead to feelings of isolation, loneliness, and even depression. Therefore, it is important for individuals to find and cultivate a sense of belonging in their lives, whether through forming relationships, participating in activities or communities, or connecting with their cultural or ethnic heritage.

Students who feel like they belong in the classroom are more likely to participate in course activities and collaborate with their peers. They feel comfortable taking risks in applying the discipline knowledge and contributing to the learning environment. When students feel like they belong in the classroom, they are more likely to have higher academic expectations for themselves and feel more confident in their ability to succeed. The sense of belonging also fosters positive relationships between students and instructors. When students feel like they belong in the classroom, they are more likely to develop positive relationships with their teachers, which can lead to higher levels of engagement and academic achievement.

Culture encompasses a set of shared assumptions and values, influencing one’s behavior, attitudes, beliefs, norms, and aesthetics [5] . The impact of cultural diversity on students' self-perceived improvement through multicultural curricula in engineering classroom activities is not studied much. Accounting for social and cultural context is key to success in product design, especially since in the process of education, students, especially students from underrepresented minority groups and international students, are engaged in a process of cultural renegotiation because of their location in a space of cross-cultural encounter. Thus culture is already a central part of the learning experience, whether or not it is explicitly acknowledged in the design of the learning experience. This paper presents various interventions engaging authentic-self and culture inspired creative design project-based learning in *freshman engineering design graphics course* with the following research objectives

(i) to identify the individual or personal characteristics that a student brings to an educational setting and their influence on students’ learning

(ii) to study the role of culture inspired creative design projects on students’ sense-of-belonging

(iii) quantify students’ perceptions on the interventions and their reflections on culture inspired creative design projects.

In this study, students incorporate their cultural / cross-cultural influence on creative home-décor products at the conceptual stages of design through creative ideation, sketching, CAD and prototyping. Students enhanced engagement and sense of belonging in learning engineering graphics is assessed through pre and post-activity reflection and quality of students' design products.

Literature

Some literature on college students' sense of belonging, role of teaching / learning methods and curriculum on sense of belonging and role of culture in creativity is briefly discussed here. Undergraduate students often find the transition from high school to college difficult. Challenges include inadequate preparation, a loss of interest, adjusting to poor instruction, discouragement due to low grades, financial difficulties, family problems, and cultural adjustment which impact the students' sense of belonging [6]. Creating a teaching and learning environment that promotes a sense of belonging can be done by recognizing and valuing diversity, and creating a safe and supportive learning environment with discipline-specific learning activities connecting with their cultural or ethnic heritage. Pedagogy and the curriculum have their main influence on students' sense of belonging by contributing to a broader 'academic sphere' that shapes students' holistic experience. Strategies for promoting belonging should therefore be contextualized, since there is unlikely to be a 'one size fits all' model [7]. A great part of creative activities arises from the interactions between individuals and their socio-cultural environments. Culture refers to the ideas, customs, and social behavior of a particular people or society. Thus, it encompasses every aspect in the way of life in people. It includes human values, beliefs, customs, languages, and traditions. Culture is reflected in how people express ideas and creativity, their history as well as in the heritage [8]. Traditional culture is being used increasingly in design creativity. Each cultural groups share a distinctive set of traditional customs, lifestyle choices, and aesthetic style. With changing consumer needs, in addition to functionality and practicability, products today must be oriented toward consumer awareness and product demand [9]. Europe and the United States specialize in taking traditional craft heritage items and combining them into brand marketing, developing them into fine boutique products. Recently Taiwan has also marketing cultural stories through creative design, commercializing local features and developing products of distinct character [10].

Methodology

Cultural products can extend the heritage and traditional values to the consumer and increase the sense of spiritual essence in human life. Perhaps the best way to extend a unique culture is to examine the impressions of the cultural object within that culture, and to promote those impressions in daily life through products whose designs are based on that culture. Globalization has led to a situation in which product design teams from one cultureal context often have to develop a product which will be used in a (totally) another cultural environment. As a result, cross-cultural product design has increased in value and interest [11]. As part of project-based learning, the freshman design course involves individual projects, where students are asked to design a 3D printable culture-inspired home décor [12]. For culture-inspired creative designs, students are encouraged to choose from a variety of cultural traits including Language, Nationality, Aesthetics (Music, Literature, art, crafts, dance), Architecture, Religion, Celebrations, Rituals, Myths, Customs, Clothing and Fashion and Ethics (hierarchies, behavior as good and bad). The cultural influence on the product should be incorporated into the conceptual stage of design, and should carefully consider what aspects of the culture are going to be included in the product. Rather than being superficial additions to the product, the cultural aspects should influence the design, usage, and purpose of the product. In fact, the product itself can be understood as a cultural contribution, empowering the student to contribute their own evolving sensibilities to the cultural marketplace. Culture and purpose should have equal influence on the final design of the product. The 3D printing project is assigned and graded in four parts: Part 1: Ideation and Sketching, Part 2: CAD modeling of parts and assembly, Part 3: 3D Print and reflection and Part 4: Digital poster with manufacturing working drawings and 3D printed product. Some of the learning outcomes of culture-inspired 3D printing project include:

- Practice product visualization / Geometric design process with given constraints.
- Use of culture-inspired features with ideation methods to improve creativity during conceptual design.
- Use of hand-drawn conceptual, perspective sketches and multi-views with dimensions to effectively communicate technical and aesthetic form details of a product to clients, fellow engineers, manufactures in the initial design process.

- Use of dimensional tolerance and GD&T
- Use of 3D CAD modeling and prototyping techniques to demonstrate the details of a previously envisioned product.
- Use of general engineering knowledge to create and defend a worthy design proposal for a desired product.

The individual project in the freshman course is meant to train students to successfully ideate, sketch, design, model and 3D print a product as per the traditional engineering practices. As a result, many of the objectives and learning outcomes associated with this project are inherently tied to introductory engineering graphics and design skills. The purpose of integrating the theme of culture-inspired design ideation is to enhance the learning process for students and provide exposure to a potentially untapped source of personal creativity. In order to fully understand the efficacy and impact of a cultural theme on students' experience during the engineering design process, a post-activity reflection and assessment is devised as an intervention method, specific to the heritage-related aspects of the project.

Results and Discussion

To assess the impact of multicultural curricula and culturally-integrated learning initiatives on students' engagement and sense-of-belonging, a post-activity reflection survey instrument is devised to (i) gauge students' interest and response to culture-based product design (ii) understand students' perception of culture-inspired design ideation and student experience. This feedback survey is presented as an optional extra credit assignment that is solely scored on completion, so as to provide students with a platform to share their honest opinions, without impacting their project grades. The voluntary nature of this assessment serves as a safeguard to prevent students from submitting skewed or irrelevant responses. Through a series of five open-ended questions, the primary objectives are to understand:

1) How culture- and heritage-related features are integrated in the form-design of the product
2) The role that an individual's background and cultural capital play in the creative ideation process

3) How a diverse and culturally-driven framework enhanced or reduced student engagement and interest in the course material

4) How cross-cultural design considerations impacted a student's self-perceived identity, sense-of-belonging, and authenticity

5) The influence of one's cultural background on creativity in product design

To effectively summarize the key findings and understand the multifaceted results of students' experiences with culture-inspired creative design projects, content analysis and text mining software are used. The primary objective of this text analytics procedure was to utilize open-ended student responses to conduct thematic analyses to find common trends across the results.

Data Analysis

To assist with the data analysis, a text analysis software WordStat and QDA Miner programs are used. The QDA Miner software is a qualitative data analysis tool to organize, code, retrieve, and annotate any data inputs. The WordStat software is a text analysis application notably for fast extraction and content analysis of key information from large sets of textual data. The software can identify key terms, extract overall meaning, highlight recurring themes, and explore relationships between data. The program takes in a variety of inputs, with critical outputs including figures, plots, and statistical summaries. These text analysis tools are capable of precise extraction and processing of large quantities of textual data. Given that the post-activity reflection responses are open-ended, this data analysis approach greatly assists in the identification of salient themes and topics.

The methodology for analysis involved creating a new project within QDA Miner by inputting a spreadsheet of the post-reflection data. The document is categorized based on each question response, and within the software, five variables were defined for each post-activity questionnaire. The project file is then imported to WordStat to manually drive the content analysis. Dictionaries and categories were defined within the program, and an exclusion list was generated to assist in efficient filtration of data. From here, statistical summaries and figures were produced as needed. A proposed workflow of this methodology is outlined in Figure 1.

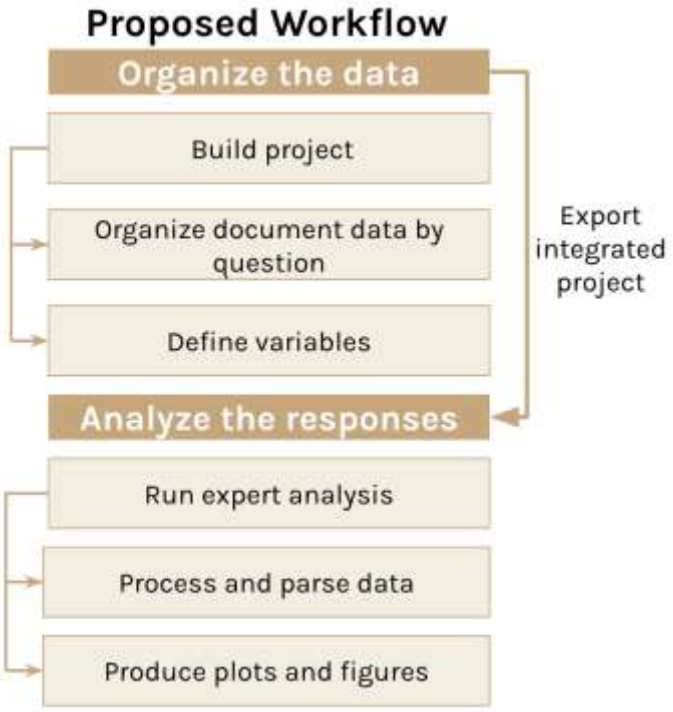

Figure 1. Proposed workflow of text analysis and mining to interpret student response data

Preliminary Results

Various culture representations in creative product design

Preliminary analysis of the post-activity survey instrument with 196 course participants in fall 2022, a total of 105 students participated in post-activity reflection survey with a response rate of 54%. Across 105 student responses, 57 unique global cultures are represented in the product design. Many student projects reflected different facets of an overarching culture or ethnicity, hence some backgrounds appeared on multiple occasions. Many students also interwove various microcultures or subcultures into their projects, by representing their religious identities or regional (state) subcultures. In such cases, these responses are grouped under an umbrella term representing the predominant culture. For example, many responses of students with ancestral origins in the United States drew from their states' cultures, mentioning regions such as Louisiana, Maryland, Georgia, and Appalachia; in such instances, the responses are grouped together under the blanket-term of American culture. Similarly, a handful of students mentioned their Irish, Scottish, Gaelic, or Celtic background, all of which are grouped under the Celtic identity.

Figure 2a. Word cloud representation of cultural diversity and backgrounds showcased in creative product design

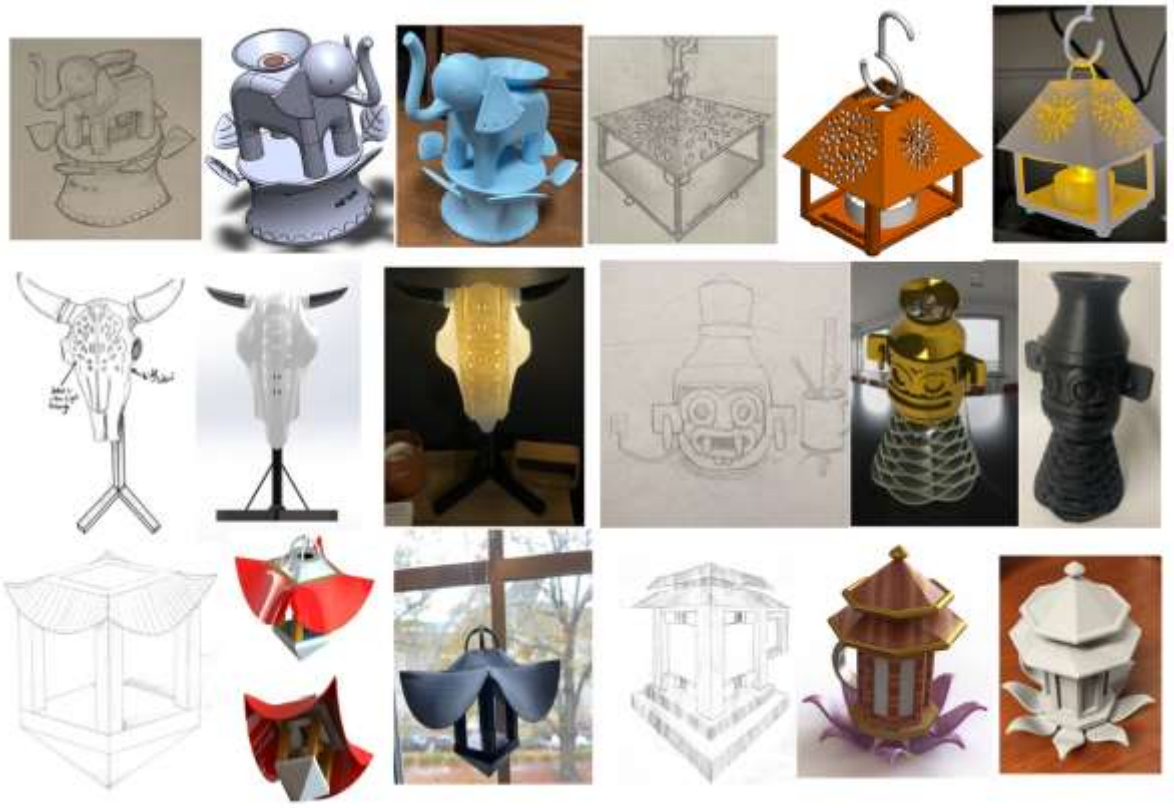

Figure 2b. Some example student work samples (Ideation sketch – CAD – 3D Print)

Among the student projects, some of the statistically larger culture and heritage representations included: Indian (16 cases), American (10 cases), Christian faith (8 cases), Chinese (7 cases), Jewish (6 cases), Italian (5 cases). In addition to these cases, a wide variety of other diverse and indigenous cultures, such as Ottoman, Iranian, Aztec, Igbo, and Mandinka cultures were also showcased. Figures 2a and 2b shows word cloud representation of cultural diversity and backgrounds showcased in creative product design with examples of student work samples showing the ideation sketch, CAD and 3D prints.

Cultural representation in creative product design: Students' reflections

Some of the students' reflections on learning, engagement and sense of belonging are presented here. A quantitative thematic analysis of these reflections is currently in progress. A preliminary qualitative analysis of student reflection statements thus far is presented further below.

> *Not only was my learning enhanced by my personal cultural background in this project, but I also got to learn more about my peer's cultural background from this project. My team members shared with me the cultural/religious inspiration behind their projects, and we all were able to learn more about each other through this project.*
>
> *Relating my culture, something that I love so much, and my major, something that I have so much interest in, made this project so enjoyable and meaningful.*
>
> *I thought it was great to see how every one of my friends in the class had a completely different design for their culture-inspired project, and it was fascinating to hear what each one meant to them. It showed how everyone has a different background, but we were all in the same classroom working on the same projects together!*
>
> *The home décor project's unique emphasis on the designer as an individual was refreshing. Making, building, and constructing are my truest forms of self-expression, so applying those outlets to convey my heritage, which is core to my identify, allowed me present my "authentic self".*
>
> *All my peers felt the same personal connection to their own projects, and whenever we discussed our progress together, the remarks and suggestions were welcoming and inclusive, which for me created a meaningful sense-of-belonging*

Cross-cultural representation

A particularly interesting result to note was that some students indicated cross-cultural representation in their design products, based on their own personal identity and upbringing. In these

cases, the student projects embodied a fusion of multiple cultures, representing the different constituents of their personal, familial, and ancestral identity.

A couple of project post-activity reflections with cross-cultural representation in the design are presented here.

In one particular case, a student describes an experience that many first- or second-generation immigrants growing up in the Western world feel– a sense of estrangement, in terms of not being identified with a single country of origin, culture, or heritage. The student describes his sentiments saying, "*I felt stuck between my mother country and where I live, not quite fitting in with either, socially, linguistically, etc*." The student explains his background, growing up in the Western world, but with his mother country's culture deeply instilled in his upbringing, and articulates the channel of expression that this project enabled:

> *"Just like me, this product incorporates aspects of Indian/Hinduism, and aspects of Western society/culture. The clean sharp lines of Western modernism, combined with the traditional symbolism and references of Hinduism represent a kind of hybridization of the two cultures. I myself am the son of immigrants who emigrated from home long before I was born, so while I was surrounded by Western society, [I] had an Indian upbringing to a significant extent. I feel a reflection of myself, both in terms of cultural design, and in terms of my own aesthetic choices within this project. Just like this project, I may not be fully engrained in Hindu tradition, but using what I have, I participate in my own unique way. I am Hindu, but I am also Westernized. Some may not like that, but I am who I am, and this project represents how I stand between two differing societies, and in a sense, by unique experience."*

> *"This project significantly increased my interest in the subject matter. It helped me feel a personal connection to what I was making, rather than just making something because I was told to. This allowed me to put in more effort, and take more satisfaction from the project, and to learn more about myself and my culture through the language of design. Additionally, the topic of culture/heritage inspiration gave me significant direction on where to start on this project, directing me in a way I probably would not have gone otherwise. This kind of project I can proudly show off to family and friends, even my grandmother. I am proud what I made, and it truly helped me feel like quite the engineer."*

In another project incorporating cross-cultural design, a student mentions designing a menorah as a décor piece, to pay homage to their Jewish heritage, while simultaneously integrating design elements to represent their Argentinian lineage from their father's side. The student mentions in his response

"to represent my Argentinian lineage (also from my father), I made my menorah resemble a sun, which is a symbol highlighted on the Argentinian flag. To help illustrate this, I used pyramidal-like shapes to resemble the sun's rays. I additionally added color and a decal to further enhance the Argentinian inspiration for this menorah design."

"Before this project, I had an understanding that engineering was a very technical and fundamental discipline. While engineering does incorporate numerous technical skills, this theme allowed me to truly explore how engineering can represent one's personal uniqueness. The idea of this even further enhances my interest in engineering as I now realize how I can express myself and my identity through unique engineering designs. I loved that I could truly highlight my cultural uniqueness through my engineering product. I am proud of my cultural heritage and was uplifted by the positive feedback I received from the instructor and the TA's. I realized that passionately exploring my Jewish Argentinian lineage could allow me to produce a project that was unapologetically me. Everyone is a unique person with a cultural identity unlike anyone else. By truly exploring one's own cultural aspects, it is possible to create a completely unique product or gain a unique experience of learning. This leads to an overall passion of a subject as the lessons learned highlight what makes each of us unique."

The fusion of cultures demonstrates the powerful influence of cultural capital students can bring to their classroom learning and discipline knowledge. The above reflections of these students are particularly heartening, and truly embody the sense-of-belonging aspect of this design activity in the course. Further, these students' post-activity reflection are adequately indicative of the importance of discipline specific culture inspired curriculum activities that can increase students' interest in the subject-matter, sense-of-belonging and creativity in the classroom.

While the overwhelming majority of responses indicated that the culture-inspired theme was well-received, there were a handful of students that expressed opposing views. One student in particular mentioned that the culture guideline "*made it harder to do the project*" because for them, "*not having much of a culture limited [their] creative ideation stage*." There were a few similar cases in which students of European descent that primarily have lineage rooted in the

United States mentioned struggles in identifying with a culture, which in turn made this project more challenging.

Ongoing quantitative thematic analysis

Thematic analysis of overall trends across the five open-ended reflection questions is currently in progress. The primary objective of this analysis is to develop an in-depth understanding of the students' perception and experiences, and to extract the key takeaways regarding the main objectives of this study. To conduct this analysis, the text mining process is performed across all student reflection responses for all five open-ended questions, independently. A collection of the common themes across all responses is generated, and filtration is used to exclude irrelevant results. Some preliminary results are shown below.

Question 1: How culture- and heritage-related features are integrated in the form-design of the product.

This question in the reflection activity is intended to connect the visualization concepts learned in the course in incorporating the culture-inspired features in the form-design of the home décor.

Question 2: What did you learn by creating this product? Describe how your cultural capital influenced or contributed to your creative ideation. Be specific.

This question in the reflection activity is intended to connect the creative ideation design activity with the course content. Additionally, this question studied how a student's cultural capital impacted their creative ideation abilities. 37 reflections reported that their cultural capital did indeed contribute to their creative ideation process, mentioning that their background "influenced" and "contributed" to [their] "creative ideation." Additionally, 58 of the reflections mentioned learning a key outcome or objective of the course, which suggests that the project did effectively reinforce and instill the fundamental concepts of engineering design. A list of the different course topics mentioned in student responses to question 1 and 2 are tabulated below.

Other more frequently occurred subject related terms in students' reflections		
Engineering sketching	Ideation process	Manufacturing process (DFM)

Product design process	Importance of tolerancing	Expression in design
CAD modeling skills	3D printing	Coherent idea convergence
Form and function design	Creative ideation	Assembly models

Question 3: Describe how culture / heritage – inspired themes for individual projects enhanced or reduced your interest in subject matter and engineering discipline. Be specific.

Among all 106 student responses, 64 reflections indicated an increased interest in the subject matter of the course and the engineering field, with 48 reflections mentioning the phrase "enhanced my interest." The frequency of other similar sentiments in phrases mentioning "piqued" or "increased" interest further contributed to this key takeaway. Many responses also suggested that the culture and heritage-inspired theme encouraged an individualized connection with the project work. Common phrases contributing to this theme included mentions of "personal" or "cultural" connection, as well as students' experiences that projects "reflected [their] culture" or "connected to [their] culture." The last predominant theme extracted from the results was that the culture-inspired guidelines promoted creativity, with 8 student cases mentioning "creative freedom" and that the project "allowed [them] to be more creative."

Question 4: Please reflect / comment on the sense-of-belonging and authentic-self aspects you experienced when working on this project. (feel-good factor).

Among the total number of 106 cases, 30 cases indicated feelings of a positive impact on their sense-of-belonging in the classroom and university community with responses frequently mentioning phrases such as "felt a strong sense of belonging", "increased [my] sense of belonging", and "feel like [I] belonged." Additionally, 32 student cases mentioned feeling a deepened sense of connection to their culture, background, identity, and local community through phrases including "connected to [my] culture", "closer to [my] culture", and "feel more connected." Lastly, many responses reflected feelings of pride and satisfaction in their work, through expressions such as "felt encouraged", "feel happy", "felt really good", and "sense of pride."

The frequency of certain themes appearing in the reflections is listed in the following table.

Influence on of cultural capital on creative ideation	**Instances**
Enhanced individual creative ideation	37
Reinforced a key course objective	58
Interest in subject matter and engineering discipline	
Enhanced interest in subject matter and engineering field	64
Fostered a personal connection to the work	27
Encouraged creative freedom	8
Influence on sense-of-belonging and authentic self	
Positive impact on sense-of-belonging	30
Deeper connections to culture, community, and identity	32
Sentiments of encouragement, pride, and happiness	28

Analysis with Likert-type scaling responses, in addition to the open-ended reflection questions is currently implemented in Fall 2023. These scaling prompts will be presented as statements to which students may select an appropriate response, based on their experience. Student respondents will be able to respond to prompts from a scale of 1 to 6, where 1 indicates strong disagreement and 6 shows strong agreement. Some example prompts are shown below.

a) Creating this product with cultural-ideation guidelines reinforced the technical topics taught in this course.

b) My personal cultural capital positively influenced my creative ideation abilities.

c) The culture- and heritage-inspired theme enhanced my interest in subject matter.

d) This project improved my sense-of-belonging and sentiments of authentic self.

e) I believe that one's cultural background has a positive influence on their creativity and unique abilities.

Concluding remarks

Based on student reflection data analysis, there are some recurring themes that can be inferred from the sentiments shared. For instance, a handful of responses mention that the heritage-inspired project theme facilitated students' interest in the subject and cultural and religious significance driving the design decisions. Many responses indicate a sense of fascination for the wide range of intentional and meticulous design decisions, as well as appreciation for the establishment of an inclusive classroom environment when sharing the story about their culture-inspired home décor design. It is clear that many students felt the project heightened the sense of respect and value for one's native culture and other global cultures. A common theme seems to be that students not only gained a greater appreciation for international cultures, but learned to rationalize how different student backgrounds inspired engineering decisions.

Further, through the application of cross-cultural design, many students expressed a reinforced sense of personal identity. The general sentiment seems to indicate that by having the opportunity to highlight their unique backgrounds, students felt an increased sense of belonging and value and ownership on the design products, while demonstrating the technical skills learned in the design course. Many individuals of culturally diverse backgrounds, such as diaspora immigrants, tend to experience a conflicted cultural identity, due to a sense of estrangement with multiple backgrounds. Oftentimes, this may be perceived as a drawback or insecurity; however, student reflections regarding this phenomenon indicate that the ability to highlight their background as enabled through this project has emboldened their pride and confidence in their personal identity.

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