Transdisciplinary design education: Do differing disciplinary backgrounds divide or unify?

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1. Introduction and Background

Design is considered an important aspect of engineering theory, education, and practice [1-3]. However, conceptualizations of design often vary dramatically based on individuals' philosophical orientations and areas of disciplinary specialization (c.f., [4-7]). Approaches to teaching and learning in engineering have not consistently engaged with the epistemological underpinnings of the engineering discipline [8,9], resulting in ambiguity over the meaning of design, and the operationalization of design concepts in informing engineering pedagogy (e.g., [10]). This tension between ambiguity and implementation is important because conceptualizations of design have implications for how faculty relate to or guide students' identity formation as designers. The lack of consensus on definitions of design is not limited to engineering. Rather, it is evidence of historic undertheorization of design in both disciplinary and transdisciplinary framings [11-13]—a situation complicated by inconsistent use of the word *design* and related terminology. The concept of design also often serves a metanarrative role, disguising differences in disciplinary design boundaries, while other approaches to incorporate design-related commitments (e.g., liberal education, ethics, or criticality) have often been marginalized in the traditional engineering discourse.

Overcoming differences between individual faculty members' understanding and definitions of design may be especially difficult within traditional higher educational institutions—particularly large public research-intensive universities, where cultural and institutional barriers have long resulted in siloing of disciplines [14]. It is perhaps unsurprising that there have not historically been many opportunities to draw together faculty from diverse disciplinary backgrounds in ways that are egalitarian and discipline-agnostic (e.g., [15]). However, multiple disciplinary perspectives are critical to aiding the development of students' design identities, and are critical to addressing the complex challenges envisioned for engineering's future. Ensuring faculty share complementary views of design is therefore critical to scaffolding the development of student design ability.

The purpose of this study is to explore the similarities and differences in understandings of design among faculty with differing backgrounds. By understanding how faculty conceptualize design, we can assess the impact of potential misalignment on a design-dependent educational environment. Faculty interviewed for this paper are involved in an innovative transdisciplinary program, in which students are encouraged to understand and activate both technical and humanistic skills and knowledge to address "wicked" design problems. The program relies on design philosophies (e.g., human-centered design) and pedagogical emphasis (i.e., studio). The faculty have spent significant time co-designing the program-level experience, and generally assumed that the group has a common understanding of concepts related to design and how those concepts may be operationalized in the classroom. This assumption was challenged as teaching practices evolved based on student responses and changing membership of the faculty group. An apparent lack of alignment among faculty inspired us to study the range of beliefs across the faculty group about design, conceptions and operationalization of design terminology, and processes. The following research questions are addressed in this study: 1) How do faculty members characterize design and the design process?; and 2) How consistent are the faculty in the way that they characterize design and the design process?

2. Study Context

This study is situated within a new Transdisciplinary Studies in Technology (TST) undergraduate program at a large Midwestern university, intended to provide students with a self-directed learning experience that engages a range of disciplinary perspectives with explicit inclusion of both technical and liberal education perspectives. Students enroll in courses within several self-selected focus areas. Each semester, they also engage in a co-taught, integrated learning experience that includes seminar-style discussions on diverse topics and readings, with studio-focused project-based curricula intended to create productive synergies from design, liberal arts, and technical perspectives. Faculty members originate from a variety of fields, including: communications, engineering technology, engineering education, English, human computer interaction design, library science, and theatre technology.

3. Methods

We conducted semi-structured interviews with six TST faculty, asking each participant to define 'design' and describe the design process they worked to foster within the program. This elaboration of design definitions was a way to concretize the conversation about design in this context, highlighting tensions inherent in our transdisciplinary curriculum. An initial round of coding of the interview transcripts involved comparing emergent themes located through an open coding approach to determine patterns of similarities and differences within and across interviews. Rough themes emerged, allowing us to describe the range of responses and articulate differences in beliefs as they impact faculty members' operationalization of design in the integrated learning experience. In a second round of coding, we plan to use a protocol coding technique [16], which is informed by *a priori* codes from the literature as well as themes that emerge from the data to extract further subtleties across all transcripts.

4. Results

4.1. Faculty Characterization of Design and the Design Process

Despite an overall sense of agreement on the definition of design, participant's responses relating to the concept of design varied, even between instructors who co-taught. Several individuals gave a definition of design that focused on creation; for example, one defined design as *"[the] manner in which you create something through the process of planning and creation and revision*." Another emphasized the importance of not limiting design to one particular type of creation: "*I find [design] to be synonymous with creation. I don't want to get too specific about what it is that a person is creating when they're designing because I think […] that could be anything*." This definition contrasted with most participants' focus on defining problem and scope, because it lacked a conscious solution orientation. This alternative perspective highlighted a major difference seen amongst faculty: *Why* designers engage in creation. While several faculty focused on meeting user needs; one faculty member never mentioned users at all.

When discussing the design process, the majority believed that there is a largely universal design process. Several participants pointed out how differences in problem, users, context, or other constraints could have an impact on the "flavor" of design process but that the larger sequence of events is generally the same. For example, one faculty member explained that when designing theatre shows, designs must be put together quickly and fit the needs of the show, but do not have to last very long or withstand continuous use, in contrast to the objects designed in some other fields. However, one individual argued: "*I don't believe [disciplinary design processes are] at all the same thing… you can't just summarize design into A, B and C. There's going to be very specific theories and knowledge.*" This response indicated a belief that the basic nature of design processes must vary between and within disciplines.

Most participants sketched design processes in the air or shared a diagram in a textbook. The number and names of steps articulated by the participants varied. One shared a diagram of a generalized 4-phase model he liked to use for teaching purposes that could be used for design across domains. Another indicated that he used a common model, which he described as "*like the scientific method blown up.*" He described the steps as: identifying the issue, looking at past attempts to address the problem, generating and examining new ideas, narrowing down the ideas, prototyping, and looping back—to be repeated four times if possible. Another stressed that the process was not only cyclical, but entirely non-linear, as multiple stages might occur concurrently, "*like the five stages of grief*".

Several aspects of the process were common across many participants. While not all used the term "problem framing," most discussed the importance of understanding the problem and context in which design occurs and the way these factors constrain the problem space. All participants indicated the value of ongoing rounds of research, although the specifics of what this entailed varied from a critical review of traditional written sources, to investigating existing products, to prototyping and user testing. Four participants stressed the importance of users and context, referring variously to the need to identify users and stakeholders correctly; focus on real needs and constraints; express empathy for users; and understanding the surrounding of context and culture. Five mentioned or implied the importance of user research to inform design. All participants stressed the iterative nature of design and the importance of ongoing testing or verification of concepts or designs. However, the nature and purpose of iteration varied among participants; five participants described a process that could move through a series of steps and then loop around again, while a subset of this group indicated that a designer could move between steps or backtrack as necessary. As one explained, "*Sometimes […] you go back and get a little more information and you refine and you go back and get a little more information. Sometimes you get to a spot and you go, 'Oh, damn,' and you've got to go all the way back or […]two-thirds of the way back to where you were.*" Five participants discussed the role of prototypes, with most of these stressing the importance of low-cost prototypes that can be used early in the design process allowing for quick feedback. Two discussed the use of modeling (e.g., CAD, mathematical

modeling) or prototyping of subcomponents where it would be too expensive or time-consuming to prototype the complete design. While most participants indicated that prototypes were useful for gathering user feedback, others stressed the value in testing whether the prototype or model met technical requirements.

4.2. How is design and the design process taught in TST?

Based on our interviews, we are uncertain whether any faculty members had explicitly defined design or design process for TST students. Most participants indicated that they did not present a definition or description of these terms, but they assumed someone else had done so. Two faculty with the most experience with the studio model indicated that they intentionally do not define design. Rather, they began by referring to students as "designers" who are in a "design class," encouraging students to enculturate into a studio culture, and allowing them to develop their own definitions of design. Most agreed that student experiences should focus more on the process and problem rather than solution. Individuals stressed being guided by theoretical principles and constraints, the responsibility of designers to change and bring something new into the world, and focusing on the needs of users.

Most faculty members had a preferred design model that they thought TST should use. Models varied in number and name of steps, degree to which one could back-track or take steps out of order, the role of research and user data, and the level of divergence to be expected across disciplines or purposes. One participant indicated that there are many models that can be used for specific purposes, but do not have to be followed directly. He described what he referred to as an "anti-process" he uses when teaching introductory design courses, "*which is explicitly trying to not articulate a design process*." In this model, students are directed to spend roughly 50% of the time at any point in the design process on research to find new information, while the remaining 50% would be spent "*trying to apply that information and doing something with it and making stuff."* Despite the variation in models described, several faculty members expressed a firm belief that the entire team used the same process. When asked what this process was, one stated "*we do the pretty common one*." Another gave a more nuanced answer, stating "*we're reasonably unified on design as a whole and general steps to go through, the way information influences it, the way the user needs to influence it,*" but then recognized that different individuals likely used different jargon. While underlying beliefs about design were not highly misaligned, it was surprising to note that instructors were not aware of students' exposure to different approaches each semester, and these issues had not been explicitly discussed with students.

5. Discussion

In this study, we identified barriers to alignment as faculty across a range of disciplines struggle to identify and implement design-related pedagogy, revealing disagreements regarding what design *is* and how faculty feel design should be activated in a learning environment. Although there are similarities in the way participants viewed design and the design process, there were also significant differences. Their lack of awareness of the differences in approach indicates that conceptual alignment may be an important area to explore when engaging in multi-disciplinary learning environments. Although exposure to a range of design problems, contexts, users, and design "flavors" is valuable to students, we suggest that without recognition of this diversity, the work of developing and crystallizing shared definitions is often seen as unnecessary or distracting. Students can be cast in the role of translator—expected to bridge differing understandings of design—while faculty are not performing this translational work due to their own lack of awareness. The shift in who "owns" or has responsibility for the translator role has significant implications for curriculum design and pedagogy.

Considering the lack of alignment in the definitions of design across our program faculty, the broader lack of consensus regarding epistemological stances across engineering disciplines in relation to design (c.f., [8,10]) or design pedagogy [14,17-18], seems unsurprising. Recent efforts to foster educational experiences that cross disciplinary boundaries create new opportunities to synthesize unique pedagogical and disciplinary approaches. Such experiences provide students tools to understand and tackle complex global challenges in ways that would be impossible within siloed disciplinary coursework. The transdisciplinary concept of design, as both an epistemology and way of acting, has proven to be one effective means of facilitating this connective process (e.g., [12,19-20]). However, cultural and institutional barriers make it difficult to introduce these types of integrated learning experiences in disciplines traditionally reliant on very different pedagogical approaches. Understanding how teaching faculty of differing backgrounds translate conceptions of design into pedagogical action therefore has substantial value for the engineering design community, both clarifying the role and extent of design conceptions, and the impact of these conceptions on the teaching and learning of engineering.

References

1. Adams, R. S., Daly, S. R., Mann, L. M., & Dall'Alba, G. (2011). Being a professional: Three lenses into design thinking, acting, and being. *Design Studies, 32*(6), 588-607.
2. Daly, S. R., Adams, R. S., & Bodner, A. M. (2012). What does it mean to design? A qualitative investigation of design professionals' experiences. *Journal of Engineering Education, 101*, 187–219.
3. Sheppard, S., Macatangay, K., & Colby, A. (2008). *Education engineers: Designing for the future of the field*. Jossey-Bass.
4. Cross, N., & Cross, A. C. (1998). Expertise in engineering design. *Research in Engineering Design, 10*(3), 141-149. doi:10.1007/BF0160715
5. Dym, C. L., & Little, P. (1994). *Engineering design.* Cambridge University Press: Cambridge, UK.
6. Pahl, G., Beitz, W., Feldhusen, J., & Grote, K. -H. (2007). *Engineering design: A systematic approach* (3rd ed.). London, UK: Springer Verlag.
7. Pawley, A. L. (2009). Universalized Narratives: Patterns in How Faculty Members Define "Engineering." *Journal of Engineering Education, 98*(4), 309–319. doi:10.1002/j.2168-9830.2009.tb01029.x
8. de Figueiredo, A. D. (2008). Toward an Epistemology of Engineering. In Goldberg, D. & McCarthy, N. (Eds.), *Workshop on Philosophy & Engineering* (WPE 2008), Royal Engineering Academy, London, UK, November 2008, 94-95.
9. Hynes, M. & Swenson, J. (2013). The Humanistic Side of Engineering: Considering Social Science and Humanities Dimensions of Engineering in Education and Research. *Journal of Pre-College Engineering Education Research, 3*(2), 31-42.
10. Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94*(1), 103-120.
11. Cross, N. (2007). Designerly ways of knowing. Basel, CH: Birkhäuser.
12. Nelson, H. G., & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world* (2nd ed.). Cambridge, MA: MIT Press.
13. Roozenburg, N. F. M., & Cross, N. G. (1991). Models of the design process: Integrating across the disciplines. *Design Studies, 12*(4), 215-220.
14. Schön, D. (1995). Knowing-in-action: The new scholarship requires a new epistemology. *Change: The Magazine of Higher Learning*. doi:10.1080/00091383.1995.10544673
15. Russell, A. W., Wickson, F., & Carew, A. L. (2008). Transdisciplinarity: Context, contradictions and capacity. *Futures*, *40*(5), 460-472. doi:10.1016/j.futures.2007.10.005
16. Saldaña, J. (2012). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage Publications.
17. Atman, C. J., Adams, R. S., Cardella, M. E., Turns, J., Mosborg, S., & Saleem, J. (2007). Engineering design processes: A comparison of students and expert practitioners. *Journal of Engineering Education, 96*(4), 359-379.
18. Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education, 101*(4), 738-797.
19. Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies*, *32*(6), 521-532
20. Krippendorf, K. (2005). *The semantic turn: A new foundation for design.* Boca Raton, FL: CRC Press.