

The Discourse of Design: Examining students' perceptions of design in multidisciplinary project teams

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The Discourse of Design: Examining Students' Perceptions of Design in Multidisciplinary Project Teams

Design is a central and distinguishing activity of engineering and one of the core criteria for evaluating and accrediting engineering programs. Design has been characterized by many different “design process” models^{1,2,3,4,5} and definitions which reflect different design approaches and philosophies. Crismond and Adams (2012)⁶ draw from many sources in their definition of design as “goal-directed problem-solving activity”⁷ that initiates change in human-made things,⁸ and involves optimizing parameters⁹ and the balancing of trade-offs¹⁰ to meet targeted users’ needs.”¹¹ From the situativity perspective,¹² design is defined as “a social process in which individual object worlds interact, and design parameters and ideas are negotiated.” Dym, Agogino, Eris, Frey and Leifer (2005)¹³ describe design thinking as “the complex processes of inquiry and learning that designers perform in a systems context, making decisions as they proceed, often working collaboratively on teams in a social process, and “speaking” several languages with each other (and to themselves).”

In today’s globally competitive economy, it is more important than ever to develop effective design skills within the undergraduate engineering curriculum. Design education has received increased attention and has motivated the creation of multidisciplinary programs focused on the development of engineering products and solutions. However, each program reflects a unique institutional and geographic context in which the program is embedded. These specific emphases and scopes impact students’ understandings of design, and how students negotiate design decisions within the project team experience. Therefore, research that can ascertain how students in these various contexts perceive and make sense of design, as well as what they believe is relevant and important in a design project, provides an important empirical basis for improving engineering programs and meeting the criteria set forth by engineering and technology’s accreditation organization, ABET, for effective engineering curriculum.¹⁴

The authors employ a discursive psychological approach to analyze interviews with students from four different institutions working on multidisciplinary project design teams. Discursive psychology is an approach to discourse analysis that seeks to analyze the ways psychological, material, and social objects are invoked and attended in social interaction and talk.^{15,16} Using this approach, we investigate the way students negotiate their specific design tasks, as well as what issues they seem to find most salient about design in their respective projects. By examining the students’ language as they describe their experiences on these teams, the researchers examine not only how individual participants conceive of and relate to design projects, but also how overarching themes indicate different programs’ framing and implementing of design in these courses. Such understandings provide insight into how young engineers approach design tasks and may create greater awareness of students’ prioritization and decision-making in a fluid and quickly changing design environment.

Discursive Psychological Approach

The authors employed a discursive psychological approach to examine these interviews for the way the students discursively manage their understandings of their specific design tasks. Discursive psychology is an approach to discourse analysis that locates meaning and reality in

social interaction, rather than as a psychological construct. Discourse in this approach is conceived as having two levels:^{17, 18, 19} the “little d” level, which refers to language-in-use or the everyday talk of social interaction,¹⁵ and the “big D” level, in which Discourses are general and enduring systems of thought that inform those social practices and thus order the world in certain ways.²⁰

This type of analysis assumes that descriptions of psychological and social objects are constructed through language and can be acted out in social contexts. As such, it examines participants’ talk to see how they use language (“little d”), and how the greater social influences from which they draw (“big D”) influence how they explain, describe, and make sense of their experiences in a given context.²¹ For example, Edwards (2003)²² used this approach to examine conflict within a marriage. Instead of looking at the talk of the husband and wife to see how it *reflected* or “revealed” psychological constructs such as jealousy, attraction, or hints of infidelity, he examined the way each participant *created* their unique social reality and psychological and emotional states by how they described each other and themselves, and how they handled their issues through various discursive practices such as countering negative images of themselves, or positioning each other as unfaithful or untrustworthy. Through this approach, Edwards was able to illuminate how the couple *socially created* their marital tensions and discursively managed their own concerns and suspicions.

This approach is a useful way to examine the engineering education design context because it illuminates the way students socially create and engage in the design and team process. We can see how students understand, create and relate to their project, their team interactions, and the greater engineering context by looking at the “little d” level of discourse for how they talk about and negotiate the salient elements of design and engineering, but we can also examine how the different programs influence and inform these social practices by offering discursive resources and lines of thinking evidenced in the “big D” level of discourse.

Method

The data examined in this paper were collected as a part of a larger study examining individual and team ethical reasoning in an engineering education context. The project involves data from four different universities that each have undergraduate engineering programs with multidisciplinary teams. While these four programs share the fundamental characteristics of being multi-disciplinary team-based design courses, the diversity across the institutions also represents the richness of cultures found within engineering. The programs all have distinct features, which are represented in the table below. Particularly important for this study are the respective orientations of each program that are detailed in that table. The programs are all multidisciplinary, comprised of students from a range of years and majors, and vary in length from one semester to several years. While each program is distinct and has unique features, they all offer students an opportunity to get practical experience with engineering and product design and development. To protect the confidentiality of the participants and the participating programs, we will refer to the universities as Institution A, Institution B, Institution C and Institution D.

The researchers conducted a total of 51 interviews with students participating in multidisciplinary project team programs across four different universities. Interviews ranged from 20 to 60 minutes, and six to fifteen interviews were conducted at each university based on student availability and desire to volunteer. The interviews were audio recorded and later transcribed for analysis. Participants provided informed consent and were compensated for their time.

Institutional Comparison Table

	Institution A	Institution B	Institution C	Institution D
Vertical integration	Freshmen-Seniors	Mainly juniors through graduate students	Freshmen-Seniors	Sophomore through graduate level
Multi-disciplinary	Yes, including outside of engineering.	Yes, including other majors, mostly engineering, business and design.	Yes, including outside of engineering.	Yes, including outside of engineering.
Multi-semester	Sections are described as “teams” and span multiple semesters. Projects can span semesters. Students can participate multiple semesters (up to all 4 years) to fulfill major requirements or capstone design. Elective.	Two semester capstone projects. Required for some majors.	Sections are described as “companies”. Projects can span semesters or years. Can participate multiple semesters or years to earn minor, concentration, or fulfill capstone design. Elective.	Projects designed to be one semester, though projects can carry on longer. All undergraduate students at the university are required to participate two semesters as part of general education requirements. Course resources focus on project management.
Orientation	Service-learning. Human services, access and abilities, education and outreach, the environment.	Capstone Engineering Design focus including business and industrial design issues. Focus on developing entrepreneurial mind set.	Business, products and services. “work like companies.”	Several. Some are specifically for business (business planning and venture analysis), some focus on sustainability, some are service-learning.

Clients	Local and global community organizations; university service and outreach units.	Mostly industry sponsors. Companies, local start-ups, student start-ups.	Primarily industry-sponsored projects, communities, government organizations.	Corporate and community partners; students, faculty, alumni, and university organizations can propose project topics.
Design	Human-centered design process.	Product development process.	Introduced through various course modules. Course document focuses on management or governance.	Project, not design, focused, for most projects.

The interview protocol was designed to engage both individual and team considerations as the participants described their experiences on their project teams. The semi-structured interview protocol was developed to probe team and individual decision-making, individual design and ethical reasoning, and general team process. Within these general areas, specific questions focused on the individual's perceptions of their role on the team, interactions among the team members, how problems were resolved, how they view their team's purpose and priorities, and questions probing team and individual perceptions of ethical issues that may have arisen over the course of the projects.

Some examples of interview protocol questions were:

- How would you characterize your team interactions as a whole?
- What is important to or valued by your team? What are your team's priorities? How do you believe those priorities came to be valued by your team?
- What is your role on the team? Do you feel like you belong? Are your viewpoints listened to?
- How and when are decisions made by your team? Who was involved in those decisions?
- Do you feel as though any of these decisions or your team work involved ethical considerations?
- How do you define ethics? How do you make ethical decisions?
- Does your team seem concerned about professional codes and/or rules/laws?
- Does your team share a common understanding of "right and wrong"?

Participants' responses to these primary questions and the questions that probed into their responses yielded the text of the interviews. Although there are procedures for text examination in a discursive psychological approach, it is important to note that discursive psychology is not in itself a methodology. Rather, it is an analytical approach that is embedded in social constructionist assumptions, as discussed above. As such, the researchers focused on the text of these interviews to investigate the engineering design process. Using a discursive psychological approach, we examined how participants described their experiences on their project teams or the "little d" level of discourse for how the students understood, related to, and engaged with the

design process--that is, how they socially created the task of design, the team member interactions that comprise it, and the greater engineering context--through their talk and the way they negotiate meanings with other team members. Alongside that analysis, we examined the relationships between the language use of participants from the same program to examine how each program played into these interactions and negotiations by offering students particular discursive resources or lines of reasoning as envisioned by the “big D” level of discourse. This second part of the analysis offers further insight into the existence of program-specific Discourses, as well as offering an interesting opportunity to compare the four programs based on similarities or commonalities between their respective students. To accomplish these analyses, the researchers performed open coding of the text as a whole, noting passages that evidenced the interpretative repertoire offered by various Discourses in the form of familiar arguments, terminology, metaphors, themes, imagery, and various linguistic devices, and analyzed the way in which the participants drew upon them in order to describe, explain, or justify their statements and descriptions of both their personal identity as an engineer and member of their team and their engagement with their particular project. The researchers focused on the text of these interviews to see how the participants use characterizations and evaluative expressions to perform a number of discursive practices,²³ such as attributing identity and motive to themselves and others, constructing their own character as well as the character of their fellow team members, countering and re-specifying others’ descriptions of their or their team’s identity and purpose, and how psychological themes were handled and managed implicitly through discursive practices.²³ The researchers completed this process for all interviews from a specific institution until commonalities emerged among these codes.

In sum, by relying on the principles of discursive psychology, this analysis examines discourse on two levels, enabling the researcher to examine both the discursive practices of the participants as well as the relation of those practices to their respective programs. We examined both the individual discursive practices of the participants, as well as identifying commonalities within each program that contribute to the development of specific characteristics unique to each program.

Findings

This study used a discursive psychological approach to investigate the way students of the four institutions draw from and position themselves in relation to the Discourses offered by their respective programs, as well as how they discursively manage their experiences and understandings regarding design.

The analysis found that a distinct Discourse emerged from each program which was evident in the participants’ descriptions of their experiences. The presence of these Discourses indicated that participants from the same program drew on similar discursive resources (or the linguistic resources offered from “big d” Discourses to communicating actors in the form of habitual forms of argument¹⁵, terminology, metaphor, and other language devices²⁴ discussed above) as they described their experiences with their respective program. These Discourses in turn seemed to influence participants’ “little d” discursive practices such as the construction of their own motives and the program’s motives. The interplay between the Discourses identified for each program and the participants’ discursive practices in describing their experiences in those

programs provides insight into the reciprocal relationship between the program's orientation, which offers specific discursive resources, and the participants' understanding of their role on their project team as constructed through specific discursive practices. The participants from each institution experienced design differently, altering their perceptions of design and their team's design priorities.

Program-Distinct Discourses

Students from Institution A drew on what we call a Discourse of Human-Centered Design (HCD) in their accounts of their motivations and intentions on their respective project teams. The Discourse of HCD was evidenced in the language usage of students from this institution. It is characterized by the framing of specific design considerations in terms of their impact on the user; descriptions of the design process as highly collaborative and interdependent; and a concern for the impact of their work on the greater community. Participants from this institution called the organizations with which each team was paired "project partners," furthering the sentiment that they were in collaboration with and service to an involved and invested party.

The language use of Institution B's participants evidenced a Discourse of Entrepreneurialism. This Discourse was characterized by an emphasis on not only a desire to create a good product, but to be innovative and proactive in their design process. These students framed their experience on their project teams as useful experiences in preparation for future careers with companies similar to those their team was working with. Those companies were referred to as "corporate sponsors," further emphasizing the sense of both freedom to innovate with the organization's support and duty to deliver products. Descriptions of the design process were highly interdependent in task-dependence; that is, the design process required members to do their part so that other members could complete theirs.

Participants from Institution C drew from what we term a Corporate Discourse. In this Discourse, the focus is on meeting or surpassing the client's needs, as well as an emphasis on the technical excellence of the product. Like participants from Institution B, these students often considered strategies for marketing to specific populations in discussions about design. They referred to their "clients," which suggests both the technical expertise of the teams as well as the somewhat more detached role of product provider. The design process was characterized as somewhat interdependent, with an emphasis on members "doing their part" and a reliance on segmented skill sets offered by different members.

Finally, Institution D evidenced a Discourse of Obligation in their descriptions of their projects. This manifested differently in different project teams, and depended somewhat on the type of client a team worked with. The fact that their projects were a component of a graded class was prevalent in many of these students' discussions, and the focus was on completion of tasks and satisfying course requirements. For other teams, there was a dual focus of corporate interest and marketability on one hand and "getting the job done" on the other. This institution had the greatest variability in the students' descriptions and discussions of their work, but the common thread was a need to accomplish whatever set of tasks or deadlines the team had set for itself. Each distinct Discourse offered specific discursive resources to its members, shaping the way they understood the project itself and their role in it. This analysis suggests that these Discourses

impacted participants' understanding of the design process, influencing their perspectives, priorities, and ultimately the team's decisions. Evidence of these Discourses emerged by examining participants' descriptions and explanations of their design projects, many of which aligned with the institution-specific Discourse identified for their respective program. Examples and further explanation is examined in the next section.

Design Priorities

By identifying the Institution-specific Discourses above, we saw how they impacted the way students perceived design on a large scale. In a similar way, those Discourses also impacted the student and his or her team's design priorities. In this section, we discuss our findings when analyzing the "little d" or focusing on participants' language use to perform certain discursive practices in characterizing themselves, their team mates, their projects and programs, and finally the design process itself. We can see the influence of the Institution-specific Discourses as they inform the social practices surrounding design and the specific design decisions students and their teams made.

Safety was a major theme across the interviews, as it is an essential component of engineering and design. Participants from each of the four institutions uniquely constructed their and their teams' motivations regarding safety. This analysis indicates that the presence of the specific Discourse identified for each institution impacted the way the participant framed their team's design priorities.

When offering justifications for their respective priorities or concerns regarding design issues, many participants from Institution A framed the design issues in terms of their impact on the user. For example, when asked what was important to her team, Cara immediately responded that safety was a top priority for her project team. In justifying or explaining this value, Cara explained that her team was "definitely working to make sure it's safe because the model itself is being used by children. And not necessarily high school students; our age range is between 6 and 13." Here, Cara made an immediate link to the needs and situations of the user when explaining the motivations for herself and her team as they worked on their project. Similarly, David explained his team's decision premises in terms of his and the team's motivations. When asked if his team had encountered any ethical issues, he responded, "Not really. I guess the closest would be last year, every time we would go down to the machine shop and get a new idea, it would be more work for us, but it would end up being safer, and we had to be like, 'Oh, I don't want to do this, but if we don't, it's potentially endangering someone's livelihood'." This quote reflects a theme throughout the interviews from Institution A, in which safety was frequently addressed as a central design priority, but with the user's wellbeing being constructed as the motivation.

Among participants from Institution B, an orientation toward the success of the product and the satisfaction of the corporate sponsor seemed to predominate in line with the Discourse of Entrepreneurialism. For example, when asked how his team considered the importance of safety in their design process, Fred responded: "You just have to make sure that safety is priority, like make sure that, I guess dumb mistakes can't get through. Especially, like, mechanically, something's that's prone to injury, you know you have to work hard at that specific component,

you know, something like that.” Here, safety was positioned as a component of the technical considerations of the product’s design, and as a potential “dumb mistake” that would impact his team’s success in developing the product. His motives were to prohibit such “dumb mistakes” from “getting through,” presumably referring to being put on the market by the team’s corporate sponsor.

This motive of designing a product with marketability and technical excellence in mind was common throughout Institution B’s participants, even in descriptions which seemed to disparage the purpose of the program.

One project team had lost their project partner, so the participants from that team were all more pessimistic about the purpose of their work or its overall importance. However, even with these descriptions that on the surface appear to indicate a lack of concern for the product, the participants’ discursive practices of countering the potential positive impressions of their project reveal a similar motivation to the highly motivated, enthusiastic descriptions common to Institution B’s participants. For example, Charlie discusses his team’s priorities, saying that they are all focused on classwork and writing papers. He offers descriptions of why his project is not desirable: “I mean, it’s tough to get really excited about the project because it’s hard to see any actual significance to it.” He goes on to describe his perspective on his team’s efforts:

and that work is strictly to get a grade, that has nothing to do with how our product will be used, whether our product will be effective or whatnot. So, really, any time we spend working on that paper, which has lately been the majority of our time, that’s only to go for the grade. Whereas if we were more concerned with developing a good product for the company, that time would have been used for doing more research, calling potential people.

Here, we see that Charlie is in fact drawing a clear distinction between the “class” aspect of his program and the professional environment or “work” aspect, and trying to discursively counter the notion that his team’s work is important now without a client. In saying it is “hard to see any significance” to his current non-product development project, he is constructing the view that tangible results and a measurable impact are his metrics for success for a meaningful project. He then clearly expresses that technical excellence and rigor *would* be a major focus, *if* they had a client. So, while on the surface Charlie’s narrative might seem a counterexample of the Discourse of Entrepreneurialism that seems to pervade institution C’s teams, analysis shows that it is in fact a reflection of the strong adherence to that Discourse which he is so clearly invoking. Charlie invokes and embodies the Discourse of Entrepreneurialism by countering the view that projects in his program *could* be non-production or non-entrepreneurial in nature.

Students from Institution C generally constructed their motivations as ensuring the satisfaction of their corporate sponsors and developing technically excellent, solid products that would serve various purposes. In their accounts, there is much less focus on the interpersonal, social, and relationship aspect of the team, as is seen among participants from other institutions. Rather, the participants constructed themselves and their program as task-focused and productivity-oriented, with a heavy emphasis on corporate policies, non-disclosure agreements, and technical design considerations. For example, when asked to consider the impact his team’s work could potentially have, Robert responded: “We know our work is directly going to affect the environment, so we are always, you know, thinking about the emission norms, maybe, you could

say the safety standards that we have to put in with all the new engines that are going to go in, the way that green cars are made... you have to make sure it's safe enough as well as it's good enough that it works for the car." While safety did come up as a concern, Robert positioned it in terms of adherence to policies governing emissions and industry standards, as well as a component of technical excellence of the design. The motivation behind ensuring safety was the client's approval or adherence to industry policies.

Throughout the interviews from Institution C, the participants demonstrated this concern for excellence and client use as central to the design process. When asked to describe her team, Krista's first discursive move was to say her team was very well-funded, and then she began to describe their product and the competitive challenges of its development. This extreme corporate orientation was evident among most of the participants' descriptions of their work. When Saul was asked how his team determines their priorities, he responded: "[The corporate client] originally had given us an outline of what the project was supposed to accomplish. So once we have that functionality, we are more or less done, but because there is no contract, we have freedom to implement other ideas as well." The motives for the work were to fulfill the client's wishes with a sound product. The goal for his team's project was described simply as "functionality."

Finally, the students in Institution D generally constructed their motives in the design process as functions of obligation, either to the professor leading the class, to the requirements of the class itself, or to the client. Nick described how his team had thought about the issue of safety as they moved through the design process:

Because working with building projects, it's been interesting, and that's always been a concern we've talked about ... you know, Third World areas, where they don't actually have any building codes, if we give them a building design ... a lot of times we're not necessarily legally obligated to worry about safety codes or building standards, but at the same time for our team, are we OK with, you know, putting out a project if we're not entirely sure about its safety? What if something happens and it hurts somebody? How does that affect us?

He did acknowledge safety as a concern for his team, but positioned it as a potential threat to his team members in terms of potential legal action. While his team was "not necessarily" forced to comply with legal standards set for safety, he considered the potential repercussions as motive for avoiding a potential safety concern.

He later considered what his team's priorities were and why, saying: "The general idea is you don't want to harm people. You know, I think it gets different for engineers, so I can't necessarily speak to that. You know, if you're putting out a building, what are the lines for safety? How do you mix that with efficiency? How much money do you have to spend to safety-proof the building? [That] kinda thing." Again, safety was considered as fulfilling an obligation of available guidelines or policies, and as a component of the practical elements of the design process such as budget constraints and efficacy of the product.

While many participants from Institution D maintained this approach to their projects, the rest of the students interviewed positioned their entire project as a class assignment. This approach was reflected in Beth's response when asked who the stakeholders were for her project: "Well, I

don't know. I guess that's an odd question, or maybe I just think it's an odd question. I guess obviously the group members and Professor Sleiven, definitely, um . . . whoever is overlooking all of the budgeting and stuff in the [institution's] office." Her team's project, the same one Nick was on, involved designing a tool to help employees of a factory more safely and easily access and transport heavy objects. When pressed by the interviewer to identify whether there might be a stakeholder at the company, she was uncertain. In describing her perspective of her team's purpose, she said: "Probably just to get students involved in working together on things they're not used to working on or thinking about. It just kind of drops you into a group environment that's not exactly like a work environment but it is similar in that you work with different people from different, well, in this case, majors." Beth's discursive strategies positioned the project as a classroom-centered environment rather than a "work environment." She constructed the program's purpose as largely experience-based, with the major benefit being the interactional element with her teammates. She did not even mention the project itself or the goals of the client, as did many other participants from this institution.

Discussion, Limitations and Suggestions for Future Research

This paper investigated the way students negotiate their specific design tasks, as well as what issues they seem to find most salient in their respective projects. A discursive psychological approach offered insight into how different programs orient themselves and their students to the design process, shaping the priorities, motivations and concerns that emerged in the participants' descriptions of their project teams. By examining the interplay between the "big D" Discourses evidenced in the students' everyday talk, the researchers examined how individual participants conceive of and relate to design projects, as well as overarching themes that indicate the way different programs frame and shape issues of design in these courses. Such an understanding provides insight into how young engineers approach design tasks and may give some insight into how they prioritize and make decisions in a fluid and quickly changing design environment.

By analyzing the interplay between the "little d" language used by the participants in describing their experiences on these design project teams and the "big D" Discourses evidenced through this talk, we uncovered program-specific similarities that seemed to inform the students' practices and decision-making processes with regard to their design projects. We identified distinct Discourses being offered by each of the programs that reflect each program's origins, structure and social context, and examined how these differences oriented their respective students in distinct ways, possibly compelling them to make different decisions, take factors into consideration differently, and perhaps ultimately impacting the products each team produces.

Our findings may be useful to institutions and engineering educators when developing their own programs and understanding the influence such programs may be exerting on their students, which encourage them to approach and engage in the design process in subtle but distinct ways. Engineering educators and administrators who are in positions to shape these programs can be mindful of these influences and could use these findings to design programs that encourage their vision of how engineering students should learn about and participate in the design process based on the outcomes they desire.

This study also contributes to our understanding of the differences and interplay between individual approaches to the same design task. That is, we can see how individuals develop different notions of their role, motivation and priorities within the team, that both shape and are shaped by their interactions with teammates and their participation in a particular program. For example, safety was a major theme throughout these interviews. Though established codes of ethics compel engineers to hold paramount the safety of the public (NSPE, 2011)²⁵, they typically do not provide the specific guidance needed to help engineers make ethically-justifiable decisions consistently, leaving room for subjective interpretation and differences in perceptions surrounding these issues. This study and the discursive psychological approach in particular can assist us in understanding these differences, both how they emerge through interaction and talk as well as how program orientations can impact how students engage in these decisions. Future research should extend these findings to provide a more in-depth examination of the influences of how institutions conduct multidisciplinary design programs to identify specific factors an institution can develop and orient these programs in desired ways. Further examination is also needed into how these orientations impact the performance of multidisciplinary design project teams in engineering education contexts to learn how the “end products” of each project may be impacted. It will be particularly important to examine whether there is a correlation between effective or successful design and development of products and the orientation of the program and student.

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