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Exploring Narratives of Team-Based Decision Making and Divergent Thinking Among First-time Designers at a Community College

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Abstract. Undergraduate engineering curricula are often structured around producing correct technical answers to well-defined problems, justifying the belief that engineering practice is focused on objective precision instead of open-ended inquiry [1]. In practice, however, engineers frequently engage in divergent thinking—the process of generating multiple novel ideas in response to a problem or prompt [2]. This paper reports on the experiences of students engaging in divergent thinking during a design incubator at the Northern Virginia Community College (NOVA) makerspace. The incubator was divided into two parts: during the first, students completed a series of spring ideation workshops focused on problem identification. During workshops, students learned structured techniques for ideation, developed and refined a problem statement, and conducted interviews with stakeholder who experience that problem. Students then returned for a summer design residency, using the tools available in the makerspace to ideate and prototype their solution and develop a formal product pitch.

After completing the program, investigators conducted 2 focus groups and 9 semi-structured interviews using Clancy's [3] protocol for eliciting narratives of divergent thinking. These data are analyzed to investigate a) what divergent thinking strategies students deployed during both elements of the program; and b) how students made design decisions when faced with multiple competing ideas or prospective solutions. Results suggest that the incubator's program design was successful in enabling students to ideate multiple competing ideas. During the design process, student teams deployed 3 primary strategies for discriminating between ideas: prioritizing team consensus, validating ideas through external feedback, and relying on a core design principle. The implications of these results for enabling and practicing student divergent thinking among first-time and beginner designers are discussed.

I. Introduction

Divergent thinking, problem solving, and collaboration are key skills for practicing engineers. Though calls for the integration of engineering design into undergraduate education are common, prior research suggests that classroom opportunities to engage in creative thinking remain elusive [4]. Given that creative and divergent thinking requires practice like any other skill, engineering students may gain the impression that creativity is not a valuable skill for engineers [5]. A key element of creativity is **divergent thinking**, or the ability to produce variant ideas or potential solutions in response to an open-ended prompt or problem. Divergent thinking is a critical skill in approaching complex problems, which typically do not have one correct, optimal solution [6], [7]. Engineering students (and engineers) often struggle with divergent thinking, often restricting themselves to known or familiar methods [8]—[10].

This paper reports preliminary results from the third cohort of a co-curricular NSF-funded student fellowship intended to help develop capacity for interdisciplinary team-based divergent thinking among groups of students at Northern Virginia Community College (NOVA) through product design. This NSF-sponsored program was structured as a design incubator and situated at a large community college makerspace with significant prototyping capabilities. Over the course of the incubator, students developed and prototyped a new product, culminating with a formal product pitch to a mixed audience of faculty, practicing engineers, and entrepreneurs.

The incubator has two main parts: 1) a series of **ideation workshops** focused on problem identification; and 2) a **summer residency** at the NOVA makerspace focused on designing and prototyping a solution to the identified problem. During each workshop, faculty facilitators led structured ideation using the divergence / convergence framework, building iteratively on the work conducted during the previous session. Student accounts of both the problem identification and solution development process were solicited in the following academic year though semi-structured interviews using Clancy et al.'s divergent thinking interview protocol [3]. This paper aims to investigate how student teams of first-time designers approached ideation and decision-making during both portions of the program. The study sought to answer two research questions:

RQ1. What behavioral and cognitive strategies do students deploy during the design process to ideate, identify, or reject potential problems or solutions?

RQ2. What are the primary discriminators that student teams use to make design decisions in a team-based long-term design project?

Ultimately, this paper makes recommendations for practitioners seeking to foster divergent thinking among undergraduate engineers, especially first-time or beginner designers.

II. Incubator Program Pedagogical Design

Ideation Workshop Pedagogical Design. The incubator adopted design thinking as the engineering design process practiced by students during their time at the incubator. Design thinking is a non-linear and iterative design process that emphasizes the gathering and analysis of data from users, rapid low-fidelity prototyping, and expansive ideation phases [11]. Design thinking was chosen for the incubator because of how long and complex data gathering and ideation phases encourage students to engage in divergent thinking. Because design thinking defers definite problem statements and solution-centered ideation until later phases, students are encouraged to spend more time exploring alternatives and revisiting user data to develop further alternatives. Table 1 provides an overview of the design thinking process along with the corresponding methods deployed in the incubator.

Table 1: Design thinking stages and methods

Process Step	Description	Methods
Empathize	The empathize stage focuses on user-centered research. Collect information from users based on a variety of sources (e.g., expert consultation, interviews, observations) and analyze it using qualitative and quantitative tools as warranted. Designers should attempt to set aside their own assumptions and place themselves "in the user's shoes."	Interviews, participant observation, bodystorming, stakeholder surveys
Define	Analyze data gathered during the empathize stage to construct an actionable and human-centered problem statement. Problem statements should be evidence-based and centered around an account of the user's experience rather than a technical or business concern.	Journey mapping, basic mixed methods analysis, user experience
Ideate	Using the problem statement, ideate potential solutions that are responsive to the statement. Multiple potential	Morphological analysis

	solutions should be created and evaluated according to a framework that privileges the user's experience.	
Prototype	Develop a low-fidelity and low-cost prototype that will aid in collecting more data from potential users. Plan to iterate rapidly on prototype results and regularly solicit input from users and stakeholders	Rapid prototyping, low-fidelity prototyping
Test	Deploy the prototype with users to gather data on their responses. Develop a testing strategy centered around observing and gathering qualitative / quantitative impressions from users.	Focus groups, user testing sessions

Design thinking is intentionally non-linear, using data gathered throughout the process to continually return to users to refine assumptions and models of their needs. Throughout the incubator, students were encouraged to see one of their primary objectives as refining their product designs through a continuous feedback loop of communication with users and other stakeholders.

Incubator facilitators also intentionally avoided "inhibiting practices" that might stop students from pursuing creative and unorthodox lines of thinking [12]. Alencar describes inhibiting practices as the actions of instructors or supervisors that signal to subordinates that deviation from proscribed methods or behavior is not tolerated. In particular, these practices are:

- **emphasis on "correct" responses & the fear of failure**
- **low expectations of student creativity**
- **expecting student obedience and passivity**
- **de-emphasis of the role of imagination**

In addition to a design framework or method, engineers also use techniques for ideation, such as brainstorming, morphological analysis, SCAMPER (Substitute, Combine, Adapt, Modify, Put to other users, Eliminate, and Reverse), and design heuristics. Daly et al [13] compared these techniques among first-time undergraduate designers and found no significant difference in expert ratings of design creativity between methods, and that traditional brainstorming produced the most designs per student participant. Given that the incubator participants were early-career undergraduates with at most sophomore standing, incubator facilitators opted to structure most initial ideation as traditional brainstorming and to introduce morphological analysis after students had generated actionable problem statements and were in the process of ideating solutions.

III. Incubator Structure

The incubator took place from late March 2025 until November 2025 and was sited at Northern Virginia Community College's makerspace facility (the "Fab Lab"). The incubator was facilitated by the author, the makerspace's director, and a NOVA Business faculty member. It had four primary components, detailed in table 1 below.

Table 2: Design Incubator Program Components and Description

Component	Description

1. Ideation Workshops	Students complete a series of 6 ideation workshops. Workshops are centered around identifying and validating a problem. No restrictions were placed on product ideas (other than legality). **Timeline: Weekly from March 23 – June 1st 2025**
2. Product Design Summer Residency	Student groups work onsite at the NOVA Fab Lab in a 4-week summer design residency. The residency includes training in physical and software prototyping, regular practice pitching their ideas, and lunch-and-learns with engineer entrepreneurs. **Timeline: Daily from May 19th – June 13th 2025**
3. Formal Pitch Event	Student groups pitch their ideas at a poster session and formal presentation to local entrepreneurs and practicing entrepreneurs. **Timeline: 1:00 – 4:00 PM on June 13th 2025**
4. Follow-up Mentoring	Student groups receive coaching during the academic year to help them develop their product ideas into portfolio elements for resumes and into actionable business ideas. **Timeline: Monthly from September – November 2025.**

Student Recruitment & Team Construction. Students were recruited to the incubator through a combination of targeted emails to advanced students in engineering and business, in-class visits from facilitators, and print & digital advertisements on campus. The application consisted of demographic data, a resume, and two short answer questions. 77 students applied to the program, of whom 28 were briefly interviewed and 24 offered a spot in the program. 24 students accepted the offer. Of those students, 12 were Engineering majors, 5 were Business majors, and the remainder from other departments at NOVA.

Prior to beginning incubator activities, students attended an in-person orientation session focused on sharing expectations and reviewing the structure of the program. At orientation, students were randomly assigned to teams of 4. Program facilitators agreed to random assignment after reviewing the literature on instructor-controlled factors in team selection (e.g., [14]. [15]), which suggests that instructor- and student-formed teams do not outperform random assignment and may result in student resentment of the instructor for team dysfunction.

Ideation Workshop Structure & Description. Ideation workshops met 6 times for 2.5 hours, with students remaining in the same assigned 4-person teams throughout. Each workshop (except the last) always included the following:

- brief period of direct instruction introducing the activities and a technique or method to keep in mind for that day's instruction.
- structured divergent ideation with facilitators "roaming the room" and providing targeted support to groups as needed
- structured convergent ideation where groups work collaboratively to combine, eliminate, and refine ideas

Some workshops had an additional task to help prepare students for other elements of the design process (e.g., interviewing users). Early workshops also included team formation exercises, including the development and adoption of a team charter, identified team roles, and a conflict resolution process.

The primary goal of the workshop series is to guide student teams during the problem identification process. Student teams began with no assigned problem or category and selected their problem themselves through multiple stages of brainstorming following by converging on a single option. Throughout the ideation workshops, students were required to continue brainstorming alternatives even as they selected and refined problem statements. This insistence on continuous refinement not only aligns with the design thinking model, but also required students to consistently think through different ways of defining their problem. Table 4 provides an overview of the activities in each ideation workshop.

Table 3: Spring Ideation Workshop Series

Session	Content
Session 1: Team Formation and Introduction to Design Thinking	**Team Formation:** students were put into their randomly assigned teams collaboratively produced a team charter. To do this, students drafted a 10 question interview protocol focused on eliciting goals, communication style, and ways of managing conflict from each other. This activity was intended to help students practice interviewing while forming team norms. **Introduction to Design Thinking:** students are introduced to design thinking and begin the ideation process by individually brainstorming 5 things that bother them in their daily life (termed 'disagio' after the Italian word for discomfort). Asynchronously, students were assigned to think of 10 additional disagios and bring them to next workshops.
Session 2: Team Role Assignment and Disagio Divergence	**Team Role Assignment:** using data gathered from the interview assignment the previous week, students propose team roles and nominate team members for those roles. **Disagio Ideation, Con't:** teams take the list of disagios they came up with (approximately 60 per group) and sort them into categories. Then, teams select one category that most appeals to all group members.
Session 3: Disagio Selection and Interview Protocol Development	**Disagio Selection:** teams return to the category that most appealed to all members. Then, teams select one among those to focus on for the duration of the workshop series. **Interview Protocol Development:** teams develop a draft interview protocol to gather data from others outside their group that may experience the same disagio. Asynchronously, each team member must interview one person using the teams' draft protocol.
Session 4: Unpacking Interview Data and Segmentation	**Unpacking Interview Data:** teams share collected interview data and draw out common themes that interlocutors spoke about. Teams revise their interview protocol to reflect their developing understanding of the problem. **Segmentation:** facilitators use a series of case studies to explain market segmentation. Teams must consider how their individual interviews might connect to broader social categories and structures.
Session 5: Concept Map Development	**Concept Map Development:** Using all the data collected thus far, teams develop a model of how their chosen disagio functions in a social context. These "concept maps" categorize classes of users and show how a team's identified problem is experienced by people.

Session 6: Problem Statement Development and Presentation	**Problem Statement Development:** using a series of worked examples, teams develop a formal problem statement along with a series of requirements that a solution should have to solve the identified problem. **Presentation:** students review a number of successful presentations and then make and present a rough draft of the problem they intend to address over the summer residency.

Summer Residency. A week after spring classes completed, student teams return to the Lab for their summer residency. The residency is full-time over the course of 4 weeks and is structured around a product pitch presentation at the end of each week, culminating in a high-stress formal pitch to an external audience at the final week. Each week, students predominantly work in teams with regular check-ins with facilitators. 2 times a week, a visiting engineer comes and shares a story from their professional practice. Visiting engineers then consult with each team and provide informal feedback. Weekly pitch practices are attended by a team of faculty advisors and program alumni, who provide ongoing feedback and guidance as the residency continues. Table 3 provides a list of final student problems and their selected solutions.

Table 4: Final Incubator Team Problems and Projects

Team	Problem	Solution
1	Open discussion of mental health is taboo within adolescent peer groups.	**Odyssea:** a networked game that aims to create space for open conversation by cultivating automaticity.
2	Public anxiety about AI resource use and job loss doesn't match the speed of development.	**ARI:** a research agenda and structure for a non-profit think tank serving gov't and the public sector
3	Shoppers often make impulsive buying decisions, choosing things they ultimately may not need	**BuyWise:** a shopping companion that compares cart contents to a list and prompts users when they go off-list
4	Nutrition information is difficult to find and interpret for the lay person	**Sifted:** an AI tool that provides user-specific summaries of peer-reviewed nutrition research
5	Government applications are an opaque and low-information process for users	**Uservices:** an integrated tracking platform for government services
6	Accessing food aid is associated with shame, despite being necessary for survival	**Heartfed:** a mobile, events-based food bank centering cross-class engagement

IV. Data Collection

Facilitators collected qualitative data from students at two time points – immediately after the ideation workshops in the form of 2 focus groups (4 students each) and after completion of the full program in the form of semi-structured interviews. Focus groups included questions eliciting formative feedback of the program (e.g., program timing & structure) and the following questions directly related to the ideation process:

- How did the workshop series support your understanding of ideation & creative thinking?
- How did the workshop series influence or change your understanding of the design process?

- How would you characterize your experience collaborating with a team during the workshops?

Focus group participants were selected on a voluntary basis and were structured to avoid multiple members from a single team on a focus group.

13 semi-structured interviews were conducted in late Fall 2025 and early Spring 2026 semesters. The interview protocol was adapted from Clancy's [3] framework for eliciting divergent thinking experiences from engineering students. The protocol moves backwards through the design process, asking students to first describe their final project and then describe the process by which their group eliminated alternative options from consideration. Students were asked to consider both major components of the incubator (i.e., ideation workshops and summer residency) separately and complete the protocol for both the problem identification and solution development processes. The following questions were asked:

1. What was the problem / solution that your team selected?
2. How did you decide on that problem / solution?
3. What alternatives did you and your team explore?
4. How did you and your team decided you were done exploring alternative ideas?
5. What were some alternatives you did not explore?
6. Why did you and your team not explore those?
7. How successful were you and your team at exploring alternatives?

Interviews were conducted by the lead author, who was also a primary facilitator during the incubator program. During interviews, investigators asked follow-up questions asking students to elaborate on their answers and to verify their understanding of the student's answers. Interviews were 30 – 45 minutes in length and conducted via Zoom.

Since the interviews were conducted by a program facilitator with a close relationship with students, this paper analyzes data from 9 student interviewees who were post-transfer or post-graduation from the college. While this does not eliminate potential biases due to the existing relationship between students and investigators, students interviewed for this paper did not depend on the any of the authors for recommendations or grades at the time of their interviews.

Qualitative data were coded and analyzed using thematic analysis [16]. Following Braun & Clarke's [17] recent caution against themes becoming "topic summaries" during reflexive qualitative analysis, themes have been structured to describe the types of stories students tell about design and divergent thinking. Initial coding was conducted by the lead author and checked for validity by the other two authors / co-facilitators. During validity checking, co-authors reviewed anonymized transcripts of interviews and discussed identified codes and preliminary themes. Themes were modified and clarified based on this discussion.

V. **Results**

Our reading of the data sought to identify how students made decisions and evaluated alternatives during ideation during both the workshop and summer residency portion of the program. Three primary themes were identified:

- **Prioritizing Team Cohesion & Consensus:** students consistently identified team concerns as a rationale for problem identification and solution design decisions. Student narratives centered around determining that all team members had a connection with chosen problems and solutions prior to moving forward. Students also frequently discussed trialing ideas with team members to check for validity (and sometimes being surprised by the responses), indicating that teams had open communication structures. Students also described *deference*, or making design decisions due to another team member's revealed preferences.

- **Leveraging External Feedback for Idea Validation:** students ascribed significant weight to verbal and non-verbal feedback from facilitators, including program guest speakers as well as core instructors. Students described using these interactions to test ideas and scrutinized the responses to direct the design process.
- **Realizing or Discovering a Core Design Principle:** students told narratives of identifying a core design principle that their team used as a discriminator to eliminate ideas or features. Student descriptions of their core principles nearly always used the framework of a "discovery" or a "realization"—centering around an unexpected pivot or shift in the framing of their problem during a moment of stress or stalled progress.

Prioritizing Team Cohesion & Consensus. Students readily spoke about the value of pursuing consensus engagement with an idea as a determining factor during ideation. For example, Student 1 talked about negotiating with her group during the ideation workshops to find common ground:

> "But we want to find a problem that all of us kind of empathize with. So that's why social problems are the ones that spoke to us a little bit more. So the process of picking a problem was pretty quick. We were like, oh, so, say, I had a problem with washing machines, but [team member] didn't. He had a problem with, say, his game consoles, but I don't play games, so I don't… I didn't have that problem." (Student 1)

Student 7, a member of the same team, described a similar experience but highlighted shared experiences between their team members, noting that "all our team members are all from immigrant ethnic backgrounds, so we all have parents with similar attitudes."

Student 1 and 7's team final product was a digital game that addressed mental health through creating space for open conversation, but only one team member was familiar with digital games. As a result, they carefully negotiated the parameters of their final product to include concerns from each team member. Student 1 commented that she was "…pretty concerned about pro gamers versus amateurs" and another team member was "concerned about safety and privacy because mental health is a delicate problem," but that ultimately was satisfied with how the final product reflected each members' varying interests. Student 7 mirrored student 1's description of the process, noting that while she didn't feel like she was a "…gamer, per se, but ultimately it was a community effort that we all bought into."

Student 2's team created an AI-based tool that provided personalized nutrition information based a corpus of peer-reviewed literature. During the ideation workshops, she stressed that the genesis of the project was "…because a lot of us had interactions with health, and particularly family members that have been affected because of bad nutrition, or because of bad habits, or because of not having a specific workout plan. And we were just really fascinated by the overlap." Student 2's reference to common personal experiences was echoed by many other student's narratives of seeking common ground—Student 3's team's project on food insecurity was spurred by shared childhood experiences with SNAP and free / reduced lunch programs. Similarly, student 4's project on AI policy was rooted in team members' shared misgivings about the technology, even if those misgivings were different:

> "…even though we were from different educational backgrounds of different majors, we all had the same common issue when it came to AI. For example, for business, one of my teammates said that she was thinking a lot about scam calls with AI, and how fraud was rampant. And one of my other teammates said that, how he was thinking about the environment, and the environmental impact of AI. And I was thinking about how companies are thinking of doing mass layoffs with AI to reduce labor costs. So, we all had different backgrounds, but it was like we found a common idea," (Student 4)

Not all students thought that consensus seeking was fully positive to their team's ability to consider many alternative possibilities. Student 5, whose team's project focused on reducing impulsive buying decisions during in-person shopping, thought that while his team's success was due in part to an idea that "…we could all relate to and be passionate about" they rejected many ideas without full consideration:

> "I feel like we definitely dove into a few of them, but we didn't go into depth in them, because we had found one that kind of made sense for all of us, and we all liked. So, I think we were successful in the fact that we found one that worked, and we did really well with it. But I think in terms of looking at other alternatives, we didn't do a whole… a really great job at going into the other alternatives." (Student 5)

Student 6, another member of the food insecurity team, agreed with student 5's concerns about consensus seeking curtailing divergent ideas. Student 6 acknowledged that "at the end of the day, it's about teamwork" but that "honestly…the food idea was not that interesting, but we ended up with that since it brought us together."

Leveraging External Feedback for Idea Validation. The design incubator built in many opportunities for students to receive feedback from external audiences. Teams regularly met with the main facilitators (the authors of this paper), but also presented draft materials each week to a faculty panel and informally consulted with guest speakers. As a result, teams used these opportunities as a testbed for ideas that they might ultimately reject. Student 3 described an "electrifying" moment when her team ran an idea past the authors of this paper and we responded very positively:

> "And I remember you guys got excited, and you said 'yes, that, that, follow that, and walk alongside that.'…I think we were trying to gauge it on what would kind of excite you guys as well, because I think…we were kind of struggling with how do we make it [their product] actually helpful and interesting and new without it being just the next new treadmill that just has fancier buttons, right?" (Student 3)

While potentially gratifying that our input was well-received, this narrative highlights how much weight students gave to facilitator feedback, which may not be warranted. Student 6, a member of the same team as student 3, described a similar process relating to solution ideation:

> " I did not like the solution first, and I came up with the solution…but since you guys said it doesn't matter how silly or stupid it sounds to just write it down…and everyone liked it!" (Student 6)

Students spoke about the difficulty of hearing feedback, but valued how it focused their products during the summer residency. Student 5 described how early drafts of their project had "bloated, unnecessary features" and that ultimately, "how we got to the product we ended up with was all the criticism." For student 5, responses from external audiences allowed his team to make difficult iterative design decisions, although he noted that the feedback was "harsh, but very warranted." In a separate interview, student 5's teammate student 8 agreed with her colleague, describing how their team chose to add a list of potential features to their mobile app as a “trial balloon” for a draft pitch presentation. She explained that knowingly including these ideas “even though some of them were just,..really, really, bad” in a draft product would help her team streamline their final version even if the feedback might seem harsh.

Student 7 from the mental health game team spoke at length about feeling uncertain during the summer incubator during the solution ideation phase. Their team spent several days debating prospective demographic targets—ranging from college students to senior citizens—and several potential forms for helping those groups—ranging from a Canvas integration to a mobile app. Student 7 described the process of seeking feedback as critical to discriminating between these competing ideas:

> “I remember we ended up shutting those down after one or two days. Because we brought them up to [the facilitators] and I think you all pushed us more towards the game. But I thought one of the app would have been more universal, to some extent more accessible…but then again, there are already mental health apps out there. The game, though, it was like this idea is unique, and nobody has really done it.” (Student 7)

Student 7’s narrative of this critical phase of the design process shows that she still feels conflicted about the direction her team took and sees potential value in other solutions. However, student 7’s team relied on facilitator guidance as a tie-breaker to finalize design choices—even though student 7 may have not been fully convinced.

Realization of Core Design Principle. A common element to student design narratives was difficulty moving from the problem identification stage in the ideation workshops to solution design during the summer residency. Students described being faced with a well-defined but often enormous and seemingly intractable problem. Teams felt mired and uncertain on the transition, but highlighted the discovery of a key design principle or reframing of the problem that allowed them to move forward and make rapid design decisions. Student 1 described her team’s difficulty selecting a prospective solution from what seemed like a wide-open field:

> “There's a lot of mental health illnesses, there's a lot of groups of ages of people, ethnicity, country… so, all of this to say is that we didn't really have any other alternatives. Until [team member] dropped the fact that, oh, you know, he was playing a game, and just in the midst of gaming…he started talking about mental health problems. It's kind of like, ding-dong! That's the thing. It's gonna be a game. Because it's the… at that point, we only know games to be the solution that produces that kind of focused state. So we could reject any other alternatives.” (Student 1)

In student 1’s experience, their problem—which centered around the barriers to talking about mental health with friends—seemed to open up too many possibilities, too many demographics, and too many factors to address. Their team was able to move forward when a team member shared an experience of being open with friends while playing a game he was intimately familiar with—and that made their team realize that they could reframe their problem around designing ways of creating space for emotional openness, which led them towards researching game design.

Student 5 told a similar story with his team, which was considering how to address impulse purchasing decisions in-store. They were bandying about multiple alternatives, including a time limit for shopping trips, a price comparison tool, and others. As part of student 5’s fieldwork, he was accompanying his parents on shopping trips and had a realization after sharing his results with his team:

> "Because it's like if you shop with your parents…and buying a bunch of random stuff they're gonna ask you questions, like do you really need that, right? You grab a candy bar, they're like, you have 10 at home, can't you just wait? Those types of things, right? And a parent is more likely to be a little bit more, like, you don't need to buy this, than we wanted, but that became the concept," (Student 5)

This field experience led his team to focus on a particular model for user experience which allowed them to comfortably reject elements like price comparison.

Student 2 and 4's projects, though significantly different, both decided to structure their products as not-for-profit. Student 2's team, which was focusing on the difficulty in finding accurate nutrition information, realized that while there were many competing platforms and products that aimed to solve the same problem, they did not address the trust issue:

> "We started thinking, like, maybe this is not as possible, like the first one trying to solve the problem of misinformation, and then the other one was the all-in-one app, and some people were, at the beginning, were really opting for that, but as we started to investigate more and thinking, like, does this model really work? Like, do people really trust something that's an 'all in one' or for-profit? (Student 2)

Student 2's team centered their product addressing the trust issue primarily, which led them to pursue the non-profit structure even in the face of pushback from visiting entrepreneurs. While thinking through the anxieties and ambivalence that the public seems to have with AI, student 4's team also realized the centrality of trust to their problem domain.

Student 9—student 4's teammate—provided a slightly different version of the "discovery" narrative. He described his team's early attempts at solving their problem as "some kind of fundamental misunderstanding of the whole design thing." When prompted to elaborate, he explained his reasoning:

> "I just think my whole team didn't know what design meant. Like, we kept trying to make a thing—do you remember when we were talking about the AI resource consumption meter? Like, the browser add-on? [INTERVIEWER: Yeah, I think I do remember.] Right, well I think we were focused on that because we felt we had to make something discrete. But then in the summer, I think during the second week, we realized that, like, an idea or an organizational structure could be a product too." (Student 9)

Student 9 situates their team's design process as being stymied because of their unstated assumptions about what would constitute a "solution" to their problem. In his telling, his team was limited by that conception until they spent some time stalled during the summer portion. Only by reconceptualizing the boundaries of a "product" could they move forward towards the solution they felt confident in.

VI. Discussion and Conclusion

The incubator is a long and intensive program that fosters deep student engagement with the problem development and solution selection portions of the design process. Investigation of student experiences with divergent thinking suggested that social factors were significant contributors to success while also limiting certain directions. For example, team consensus was prioritized over exploration of alternatives, which may have resulted in projects that were built on the coincidence of shared experiences rather than taking a more "objective" stance. While students indicated that the shared sense of ownership led to projects that could be valuable and meaningful to all team members, prioritizing consensus and common experience may undercut the centrality of empathy with those unlike yourself in the design thinking process.

Team emphasis on consensus is also a likely consequence of incubator pedagogical design. Especially during the spring workshops, facilitators emphasized elements of successful team formation and operation, including open communication, development of team charters and formal conflict resolution processes. Facilitators also checked in with teams regularly to verify that teams were functioning, though rarely intervened directly outside of those check-ins. Given that functioning in a team is a key professional competency—and that effective intrateam communication and consensus building is necessary to team function—engineering educators should continue to emphasize effective team practices as foundational to the design process.

Similarly, the role of external feedback as a determinant of design decisions is worth examining. In some cases, students gave much more weight to this feedback than their own instincts and team decisions, even scrutinizing body language clues to determine the valence of facilitator opinions. While students intensely value the ability to seek feedback from expert interlocutors (including program guests), this external guidance is clearly shaping student projects—and program facilitators are providing the most accessible feedback to students. While first-time designers are more likely to require scaffolded assistance during decision making, facilitators must take care that they are not leading the design process themselves.

In professional practice, seeking and integrating feedback from more senior engineers is a critical component of navigating the workplace. Likewise, being able to understand and integrate that feedback into design practice is a communication and collaboration skill. Students clearly felt confident presenting ideas—even half-baked or preliminary ones—to program facilitators and guests. This suggests that the incubator was successful in creating the conditions in which students were able to seek feedback and advice from more experienced practitioners without fear of social or academic consequences.

The above results, however, suggest that creating the conditions for students to comfortably receive design feedback is not in itself sufficient. Students also must be able to interpret and incorporate that feedback, weighing it against their own knowledge and emerging design practices. For pedagogical approaches that allow students significant latitude when choosing a problem to work on, teams may be more knowledgeable than their instructors. During the incubator specifically, teams had conducted at least 8 prospective user interviews and consulted with at least 2 outside experts by the time the summer started. Instructors of first-time designers may need to provide students with frameworks to interpret outside guidance—which is nearly always well-meaning but may come from sources not as immersed in the problem as the students themselves.

Student narratives about realizing or discovering some critical design feature show the centrality of allowing for periods of uncertainty and unproductivity during the design process, especially for first-time designers. For students in the incubator, their "discovery" nearly always turned out to be a pivotal moment in their project's development and became central to how they approached developing and pitching their product. While it's difficult to pinpoint a specific shared element among how students arrived at those realizations, they did all stem from being given space for uncertainty. Especially during the summer portion, student teams were allowed to spend time making little progress and few decisions of importance. During these periods, facilitators would regularly check in but not enforce deadlines or set project milestones. As a result, student progress was uneven between teams—some moved forward quickly while others might lack a clear direction for a significant portion of the program.

On first read, this theme of discovery might seem at odds with student reliance on external feedback. However, these two themes may be understood as mutually reinforcing, to an extent—students were given space to debate, consider, and create competing ideas and solutions, and brought those ideas to facilitators and guests to help them discriminate between competing options. Teams then viewed expert response to their ideas as a key deciding factor enabling a final determination on which direction to choose.

Notably, none of the interviewed students spoke about difficulties or inability to come up with alternatives during the incubator. Instead, the students focused on how to discriminate or choose between competing ideas and solutions. Students were able to explain which alternatives they considered, why they rejected or accepted those alternatives, and provide a clear rationale for their final product. This suggests that the incubator program design was successful at fostering an environment that encouraged the development of student divergent thinking practices. Compared with typical design courses, the incubator had significantly more emphasis on ideation and problem identification, and much less emphasis on technical specification. Howe & Goldberg's [18] survey of US engineering schools' design courses suggest that while entrepreneurial approaches—such as the one deployed here—are gaining in popularity, the majority of design prompts are sourced from industry or from a faculty member's research agenda. As a result, students have less engagement with problem identification and correspondingly spend less time on ideation and divergent thinking.

Comparative studies of design courses (e.g., [18]—[20]) suggest that design education typically takes place during the senior year and is not scaffolded by earlier team-based design experiences. The incubator presented here provides a model for an earlier interdisciplinary encounter with design that privileges divergent thinking and problem identification. The data presented above suggest that educators interested in a similar intervention should consider several factors during their own development process. First, design programs that include robust, iterative feedback cycles from industry guests or instructors need to prepare students how to interpret and actualize that feedback. Part of the learning process should entail building student confidence in their own knowledge—especially when that knowledge is based on specific user research that only student teams have done. Additionally, students (and instructors!) should be allowed to experience stalled progress or ambiguity, even if that means student teams are not in lockstep during the design process.

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