Designing Moonshots

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***Abstract*—This Innovative Practice full paper presents an immersive class model, "Designing Moonshots," which harnesses design thinking principles to equip students with theories, skills, and trajectories for designing moonshot projects. Through user interviews, expert feedback, and student-led "makeathons," participants reported a significant development of their abilities to need-learn and work with peers. Students also noted an increase in agency towards tackling systemic issues, the acquisition of novel problem solving strategies, and the discovery of new fields of interest. Implications of this research demonstrate that the pedagogical synthesis of the design thinking approach and moonshot solutions holds promise for a variety of skills that are often omitted in traditional education.**

***Index Terms*—moonshot, design thinking, need learning, makeathon, course**

I. Introduction

Since its inception as a professional field, design has increasingly been studied, adapted, and applied to a gamut of fields as a framework for human-centered problem-solving [1]. "Design thinking" - a "sweet spot of feasibility, viability, and desirability" - takes into account "real needs and desires," fostering greater integration of empathy, prototyping, and exploration of new insights within both professional and educational settings [2]. Applying specific filters to guide the trajectory of design thinking projects can enable innovators to focus their creativity within a specific sphere. "Moonshots" have been defined as bold efforts to achieve significant breakthroughs in tackling complex, large-scale challenges [3]. The pursuit of moonshot projects stimulates intensive, collaborative, and ground-breaking human efforts, with extraordinary impacts on both end-users as well as on those involved in their making [4]. While the pursuit of moonshots has become a guiding principle for initiatives involving companies, governments, and research organizations, there is little literature establishing the teaching of moonshot pedagogy in educational spheres, and even less so using moonshots to specifically contextualize design thinking. This research seeks to answer the question: *How can design thinking focused on moonshot education empower and inspire students?* The paper presents a novel course structure to synergistically weave together moonshot solution frameworks and design methodologies.

II. Moonshots in education

Studying the effects of using moonshot approaches to solve systemic societal issues has produced an emerging consensus: challenging students to address broad, unanswered, and difficult issues through "big ideas" engenders uniquely positive learning outcomes [5]. A deeper and more complete ontology is promoted through moonshot thinking since attaining such solutions requires interdisciplinary knowledge and methodologies [6]. Further, the significant scale of stakes involved in solving systemic problems of the moonshot caliber fosters a sense of "prosocial, self-transcendent purpose" that motivates students to "sustain academic self-regulation" and maintain focus over time [7]. However, there is a dearth of literature on methodologies for integrating moonshot design within educational spaces, with correspondingly even less or close to no available literature recommending strategies for educators to effectively implement moonshot thinking in educational practice.

Education literature on design thinking is far more extensive than the moonshot literature. From theoretical research outlining distinct stages of design to practical studies documenting design thinking course outcomes [8] [9], researchers have embraced design methodologies as empowering for collaboration, creativity, and confidence [10] [11] [12]. Students applying design thinking in "multi-disciplinary teams [to] solve difficult real-life problems" gain a sense of motivation through open-ended problem solving [13] [14]. However, design thinking literature has largely focused on the process instead of the product [15]. From an educational standpoint, little investigation has been conducted into exploring what *types* of problems might prove most pedagogically fruitful when approached from the means of the design thinking process.

The course designed and evaluated herein, "Designing Moonshots," unites moonshot and design thinking to address respective gaps in their educational praxis. By complementing the design thinking method with a moonshot solutions trajectory, the course simultaneously addresses the gap of educational means in the moonshot literature and the gap of educational ends in the design thinking literature. Because applying design thinking and working on moonshot problems both engender similar learning outcomes, they are inherently apt for synthesis.

III. Research Questions

Two research areas are identified to study how design thinking focused on building moonshots can empower students in the classroom:

To address the lack of educational methods in the moonshot literature:

(1) Does design thinking provide a means to facilitate the development of moonshot solutions addressing systemic problems? Specifically, can the Designing Moonshots class establish effective design methodologies for student projects targeting moonshot goals?

To address the lack of substantive goals towards which design thinking is best applied in the classroom:

(2) Does incubating moonshot prototypes provide tangible end missions for students to meaningfully learn and practice the design thinking process? That is, can the Designing Moonshot class enhance students' design thinking skills by providing moonshot goals to strive toward?

IV. Methods

A. Course Motivation

To lay the groundwork for investigating the two posed research questions, an experimental course was established, coined "Designing Moonshoots." Design thinking methodologies are taught with iterative practice through hands-on prototyping and user interview experiences. Solving moonshot scale problems is explicitly defined as the ultimate objective of student projects. Analysis of student outcomes from the combination of moonshot goals with design thinking methodologies reveals introductory insights that address the two research questions. In answering these two research questions, Designing Moonshots establishes the first step towards larger scale application.

B. Course Description

The Designing Moonshots class was taught during the Winter 2019-2020 academic quarter at a private, Western U.S. University, hosted by the Mechanical Engineering Department and sponsored by a faculty member. The class was offered for 2 units on a credit/no credit grading basis, with admissions conducted by application according to criteria of student interest, initiative, and commitment. 14 undergraduate students who completed the course held a variety of different majors and represented each grade, from freshmen to seniors.

The course was divided into 5 modules, each covering a different area of global need to maximize exposure across disciplines for innovative moonshots: 1) wellness, 2) political governance, 3) climate change, 4) education, and 5) global health. Moonshot design content was organized within the framework of "How Might We's (HMW's)," exploratory questions for provoking discussion, interviews, and innovation within each module. HMW's were intentionally constructed as broad, general prompts to encourage students to embrace ambiguity and further generate more nuanced questions.

The class met weekly, with each module spanning two weeks according to a two-pronged course structure: Week A) introduction to the field and an intimate discussion with a guest expert, and Week B) student presentations of findings from user interviews and subsequent small-group "makeathons." For each module, students were assigned into randomized teams of 4-5 students that tackled a specific HMW through collective user interviews and a subsequent "makeathon." A detailed breakdown of the course content is presented in Table 1 of the Appendix. Terminology coined for assignments and class components can be found in Table 2 of the Appendix.

Week A classes were designed to facilitate "need-learning," a term we propose as a nuanced method of "needfinding" presented in traditional design thinking curricula. "Need-learning" emphasizes the learning of existing needs to be fulfilled rather than observing needs on one's own. Need-learning is especially desirable in approaching moonshot solutions because complex, systemic issues are often too broad to observe meaningfully as a non-expert individual. To accomplish "need-learning," Week A classes invited experts to guide a conversational, student-driven discussion that focused on speakers' insights into relevant and pressing problems.

Makeathons were designed to give students iterative practice in designing projects, addressing learned challenges head-on, and uncovering modes of failure. Central to teaching design principles within a classroom is the facilitation of authentic design experiences that enhance understanding of both the process as well as the product [16]. Students directly applied content they acquired from interviews, readings, invited speakers, and discussions to synthesize their makeathon projects by working collaboratively in a timed setting.

C. Research Methodology

In collecting data throughout the course, emphasis was placed on the need for "rich, illustrative examples" as a robust form of qualitative inquiry espoused by similar course-based research papers. This qualitative research design surfaces a detailed understanding of the dominant thematic outcomes of Designing Moonshots from the perspective of all students, who were required to respond to a limited number of prompts regarding their experiences during the academic quarter.

As such, the data is composed of student responses to a set of questions (see Table 3 in Appendix), collected once at the midpoint and again at the conclusion of Designing Moonshots. For privacy, the names of all participants are hidden. The focus of the paper is not to track the development of individual students, but rather to uncover the learning outcomes of the course as a whole.

In drawing thematic conclusions from student responses, we employ two qualitative verification techniques: prolonged engagement and rich description. Prolonged engagement requires that the themes surfaced from student responses must hold across an overwhelming majority (> 10) of students between the midterm and final surveys. Rich description requires that the questions asked of students satisfy two requirements. First, they must allow for negative options (such as "I did not gain any skills from this class"). Second, they must prompt additional description (answers such as "Yes" or "No" are not acceptable).

Limitations to this research methodology include three factors. First, students may respond more positively to protect the emotions of the instructors; however, we consistently solicited constructive criticism from mandatory weekly attendance forms that invited critiques of the week's course offering. Second, students who choose to participate in a design course may be more favorably inclined towards positive emotions regarding design methodologies. This effect is mitigated by avoiding survey questions that ask about "design thinking" specifically, instead prompting students to report their own learning outcomes. Finally, a core limitation consists in the small sample size of students. Because there is no guarantee that these students are representative, the generalizability of the results is inhibited. However, generalizability is not a focus of this work; rather, the goal is to outline the major thematic learning outcomes of these students in specific and vibrant detail. This paper sacrifices broad generalizability in order to pioneer a focused example of a course structure that could warrant future investigation and adoption.

V. Research Outcomes

A. Need-Learning

A key objective was met in teaching students the value of need-learning as a nuanced way to approach needfinding. When students were surveyed for the "top three skills, insights, mindsets, facts, takeaways, that [they] have learned from this class," student responses highlighted "the advantages of a problem-first vs. solution first approach," "it's usually better to simply build on already existing infrastructure than to build your own," and that "to truly build a moonshot, one must first understand the incentives and underlying mechanisms that govern that particular industry, prior to building any sort of technology." Key student realizations aligned directly with the course goal of understanding problems before considering solutions: "I've learned how many problems there are in the world that no one is adequately working on" and "[the course] taught me that you don't just need to try to find a solution, but need to really understand a problem first." The moonshot orientation of the course effectively guided students to prioritize problem comprehension before solution development. Even as the course intentionally refrained from explicitly spelling out design thinking methods, the activities students completed through the course implicitly drew out these concepts via practical application. Thus, the course's focus on sparking moonshot solutions organically instilled design methodologies.

B. Teamwork and Peer-Learning

Another crucial takeaway was students' acquisition of effective collaboration practices and teamwork skills. When prompted to identify "one concept (if any)" they learned from the class that "they don't think [they] could have learned in a 'traditional' lecture or seminar setting," students overwhelmingly responded that their ability to ideate with and learn from their peers improved. Students learned "how to collaborate with equally motivated students" and noted that "[it was] amazing to be able to talk and work with them." Another student mentioned that "brainstorming solutions with a group" allowed them to "push back on ideas as well as have [their] own ideas tested." Finally, a student noted that the class made them "a better people-person." Again, the acquisition of the core design thinking skills of peer learning, feedback, and brainstorming mechanisms reported by students is made more striking by the lack of explicit instruction on effective design collaboration; these skills surfaced naturally through interactive experiences.

C. Agency, Confidence, and Ambitious Thinking

Students reported increased confidence in their own ability to ideate, execute, and adjust their design-thinking trajectories accordingly in the face of barriers and failures. This manifests in three primary areas: project execution, conducting interviews, and perceived personal potential and impact.

Students approached problems with increased agency and confidence throughout the class. Students reported that they "gained more practice at just producing half formed ideas to build off of" and learned "the ability to compromise and not strive for something 'perfect' but rapidly iterate on things that get the job done." Moving beyond the constraint of crafting "perfect" solutions is particularly valuable in offsetting the model of "perfectionism" that can arise in traditional academic settings. Especially after the makeathons were restricted to project solutions that were not mobile application-based, students reveled in their expanded potentials, citing learning "how to... instead, go for systematic change." These reflections meet research objectives in empowering moonshot projects.

In conducting interviews, especially with experts and those seen as "unreachable," students reflected that "it turns out if you want to ask experts for their opinion, many of them are willing to chat and provide insight." One student's top takeaway from the class was "the importance of actually reaching out to professionals." Interviewing is reported to be impactful as an extendable and improvable skill: "The idea that… I can reach out to industry leaders and expect a response/willingness to help – I want to make use of this more often."

The class also instilled hope and optimism in many students' views of their own ability to contribute meaningfully, with students reflecting that "you don't need to be an expert to have a moonshot idea" and "I think it's counteracted a really defeatist attitude I didn't realize I had about really massive problems (mental health, climate change, educational systems) and has given me some hope that the information and expertise we need to solve these issues is out there – we just need to be proactive about searching for it." Another student reported a similar mindset shift, reporting that "it has changed my approach because it has made me realize that change is possible – and this is a really powerful idea."

Here, the design methodology processes of embracing failure and promoting frequent interaction with experts contributed towards a sense of agency and confidence towards developing moonshot solutions. In Sections *V.A* and *V.B*, the moonshot disposition facilitated the acquisition of the design thinking skills of need-learning and teamwork. The inculcation of a more confident approach to tackling large problems highlights the corresponding ability of the design thinking methodology to imbue in turn a moonshot disposition.

D. New Perspectives on and Approaches to Problems

Students detailed a wide variety of new perspectives on and approaches to problem solving. Notably, students reported heightened awareness of the many problems that they may encounter in daily life: "I think more about how problems around me can be fixed," "I have been more cognizant of the ways the university promotes recycling... after discussing it at length," and "I think I see problems and solutions in more things now." Further, this awareness is also coupled with an epistemic humility: "[interviewing experts] a really humbling experience" that "has made me realize that I don't know as much as I think I do."

Students outline new strategies for problem solving such as rapid prototyping, which taught one student to "enjoy having a time limit because [they are] someone who can take an idea and run iterations on it forever." Further, students reported learning the ability to "decompose" problems, with multiple students' comments resembling this one: "I tend to think of problems more as a maze of smaller problems than one giant problem now." In addition to breaking large systemic issues into more approachable subproblems, many students noticed that they think more "holistically about solving a problem," with one student remarking their "need to learn all the different aspects/views of a problem before coming up with a solution."

E. Exposure to Specific Insights and New Interests

Students acquired a more comprehensive understanding of globally impactful moonshot solutions from the incorporation of expert testimony and opinion. Students were mostly neutral in responding to the likelihood that they continue working on a problem, idea, or project that was discussed in class; however, students overwhelmingly agreed that they learned new problem areas that they are interested in solving. These results uphold the intention of the course not to immediately produce moonshot solutions *per se*, but rather to equip students with the interests and skills to do so in the future.

Specific new areas of problem-solving were voluntarily raised in survey responses, including "[increased] interest in edtech and innovation processes," "[guest lecture's] insight on approaching education," and "carbon removal from the atmosphere." More overwhelmingly, students praised the broad scope of topics, learning "how to appreciate industries/worlds that I never thought I'd be interested in, and how to create with even broader factors in mind." These results meet the course goal of exposing students to problem areas as opposed to immediately rushing to work on premature solutions to complex problems. This grants students an improved platform from which they can grow projects to the moonshot level using learned skills.

VI. Outcomes in Response to Research Questions

The reported research outcomes from the Designing Moonshots class address the defined research questions from a variety of angles.

In response to question 1, Designing Moonshots shows that design thinking offers a valuable methodology to facilitate the development of moonshot solutions in student projects. The explicit incorporation of design mindsets empowered students to take small, iterative steps towards an otherwise overly broad and ambitious systemic problem. In structuring moonshot content throughout the class, balancing focus with broad impact when defining each of the 5 Global Needs modules of the class resulted in students' heightened and oftentimes newfound awareness and interest for engaging with diverse global issues, which were clarified by the needfinding and prototyping process offered by design thinking. Specifically within the design process, intentional incorporation of expert testimonies, interviews, and perspectives in week 1 of each module fostered specific engagement for actionable next steps that served as motivating launching points. These tangible, need-driven starting points translated to students' long-term interest in tackling moonshot projects even beyond the course, as students developed a methodology for breaking down nebulous and overly broad problems into specific and manageable user needs. Iterative rapid prototyping sessions further empowered students with the concrete skills to tangibly act on the user research and problem definition obtained from interviews. Students across the board reported increased perceived ability in their ability to positively contribute to moonshot solutions as a result of the design thinking methodology.

In response to question 2, Designing Moonshots shows that establishing moonshot goals facilitates the learning of design thinking methodologies in the classroom. The inherent complexity and expansive scale of moonshot solutions forces students to reckon with problem decomposition; this provides students with a comprehensive, immersed design experience where prototyping, user interviews, and constant iteration are not only "nice to have," but necessary due to the gargantuan initial scope of moonshot problems. Further, makeathon sessions explicitly encouraged students to design in moonshot-driven trajectories and contend with the long-run impact of their initial work, which drove students to rely on and appreciate the design thinking method as a powerful methodology across all stages of development and implementation. Overall, the scope and ambition of moonshot goals helped to clarify for students why the design thinking process is necessary, and also how it can be applied in highly impactful ways.

VII. Implications for Future Course Design

A. Recommendations for Educational Curricula

This study presents a foundation for establishing future courses with similar structure and content. To evaluate the overall value of the course, students were asked "How likely are you to take more courses in the future that are similarly structured?" 75% of respondents responded positively with measures such as "definitely, very likely, and extremely likely." Students that were not enthusiastic cited an external reason (e.g. fulfilling degree requirements and suitability of other course material to the class structure) rather than intrinsic components of the course. A further metric for evaluating student attitudes towards the course is students' willingness to recommend the course to a friend. In both midterm and final surveys, students were asked "how likely are you to recommend this class to someone else?" on a scale from 1-5, with 1 being "unlikely" and 5 being "very likely." All respondents in both surveys marked "4" or "5", demonstrating strong support for the course's value.

Students reported increased value in comparison to traditional lecture-based classes, stating, "this course taught me that I'm not really learning all that much in lectures anymore. This, however, was v[ery] different." A key difference can be summarized with the response that "lectures teach AT you, not with you." In differentiating from lectures, makeathons were amongst the most enticing components of the class: they engaged interpersonal engagement and shared learning, which can be incorporated into curricula in a multiplicity of fields. A response that stands out in this regard: "this [course] was fully immersive and I was able to actually engage and try ideating with amazing people. That was such a special thing." Specific recommendations for facilitating similar engagements in other courses include: "working with groups very quickly on different important projects," "learning from other people's learning," "the Socratic model of the classes," and "working in interdisciplinary groups."

Guest experts were invited to speak in an intimate and Socratic setting that evoked conversation as opposed to presentation. Students responded that they "liked the guest lecturers, and the granularity of questions we could ask them owing almost entirely to the class format." This format generated enthusiasm that can be applied to other fields. An example extension of open-ended interview-based learning in classes with more traditional content, such as thermodynamics, might involve inviting students to discuss the relevance and applications of thermodynamic principles learned in class with a renowned rocket scientist.

B. Improvements

Future iterations of this course will focus on improvements in student engagement. An initial improvement includes expanding both the overall duration of the course and the time spent in class each week. A recurring theme in students' responses was the desire for increased depth in course content and projects, summarized through the response, "I think if the class were like a 4 or 5 unit class [as opposed to 2 units] with more time commitment from the students, even more interesting things could have been done and more behavior changes would have occurred."

VIII. Conclusion

Designing Moonshots is proposed as a novel course structure that synthesizes design thinking and moonshot solutions in order to address needs in both fields. The application of the design thinking process to the development of moonshots engenders an educational environment that compounds the existing pedagogical strengths of both approaches. Student responses to Designing Moonshots indicate that major learning outcomes include need-learning, teamwork skills, and the agency and confidence to tackle systemic issues. Further, students gained exposure to a variety of new problem solving strategies and fields of interest. Despite these promising outcomes, research suggests that the course structure would benefit from further expansion and exploration. Ultimately, Designing Moonshots is a first attempt at pioneering an educational model that engages student change agents to take charge of their own education.

IX. Acknowledgments

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X. Appendix

TABLE I
DESIGNING MOONSHOTS COURSE STRUCTURE

	Week A	**Week B**
Before class	• Read entire Design Brief • Contact at least one ”expert” in the field	• Complete interview with contacted ”expert”
During class	• Topic discussion • Conversation with invited speaker	• Interview insight sharing • Makeathon + makeathon presentations
After class	• Attendance feedback form • Conduct interviews	• Reflect on makeathon project • Attendance feedback form

TABLE II
DESIGNING MOONSHOTS DEFINED TERMINOLOGY

Term	**Definition**
Design Brief	Documents distributed before week A of each module, consisting of a brief introduction to the global area of need, assigned readings, a biography of the speaker invited to the Week A class, and a different “HMW’s” assigned to each student group. An example of a design brief used in the course can be found at this link.
expert	any person with experience, unique insights, or stakes in the module’s content was qualified to be an “expert” to interview
makeathon	Collaborative problem-solving sessions within student groups to design a “moonshot project’ within the scope of the module’s content, drawing from gained knowledge from readings, topic discussion, speakers, and other research
makeathon presentation	Short presentations of makeathon projects to the entire class, with open questions and feedback

TABLE III
MID-CLASS AND FINAL EVALUATIVE QUESTIONS

Question	**Response Type**
What are the top three skills, insights, mindsets, facts, takeaways, etc. that you have learned from this class? Be as specific or as general as you’d like.	Long answer text
What is one concept (if any) that you’ve learned from this class that you don’t think you could have learned in a ”traditional” lecture or seminar setting?	Long answer text
How likely are you to continue working on a problem, idea, or project that was discussed in class after this class?	Rank: 1 (very likely) to 5 (not likely)
To what extent have you learned new problem areas that you’re interested in solving?	Rank: 1 (strongly disagree) to 5 (strongly agree)
How likely are you to take more courses in the future that are similarly structured? If so, what aspects of this course make you say so?	Long answer text
How has this class changed your approach to /understanding of solving issues you are interested in (if at all)? How/why has it (not) changed your approach/understanding?	Long answer text
Has this class tangibly changed your mindset or behaviors outside of class? If so, how? If not, why?	Long answer text
Has this class tangibly changed your mindset or behaviors outside of class? If so, how? If not, why?	Long answer text
Has this class inspired for you - however tangentially - any new ideas, solutions, or interests? If so, how and why?	Long answer text
Has there been an ”aha” learning moment for you during this class? If so, what?	Long answer text
How likely are you to recommend this class to someone else?	Rank: 1 (I would never) to 5 (I would certainly)
Write a course description 2-3 sentences for [Designing Moonshots].	Long answer text

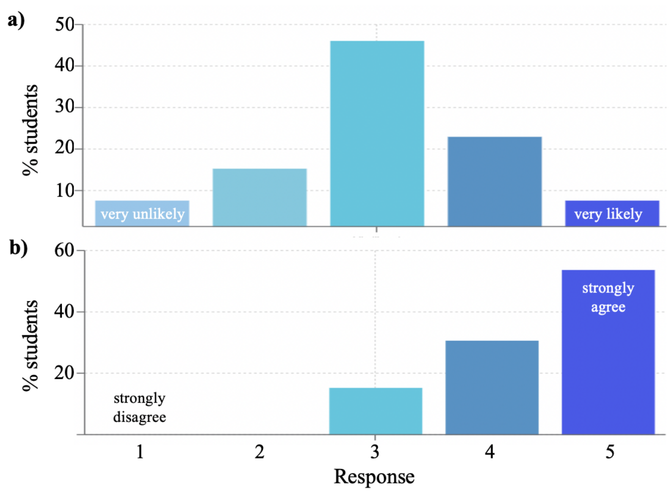

Fig. 1. Distribution of survey responses to: a) How likely are you to continue working on a problem, idea, or project that was discussed in class after this class?, and b) To what extent have you learned new problem areas that you're interested in solving?