DESIGN AT BROWN

DISP FINAL REPORT AND RECOMMENDATIONS

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ABSTRACT

This paper seeks to explore the existence of Design at Brown University. We aspire to understand how Design could be represented as an academic field and centralized in terms of ideology and resources. Through several lenses, we investigate the concept of Design as both a method of practice and field of study. We explore its need within higher education and industry, as well as define design within Brown University and the School of Engineering. Examining classes, design spaces, student interest, and faculty interest, we then consider the state of Design at Brown. Next, we review Design at peer institutions, seeking to elucidate what is considered standard at other schools and ultimately find that each instance of Design is unique. We investigate the industry and aftermarket for a Design degree, reviewing job postings and interviewing several companies. This research demonstrates that Design is a school of thought that must be a part of Brown University. As such, we recommend these potential options to expand Design at Brown University: augmenting Design curriculum, creating a concentration, implementing advising, hiring Design faculty, and considering the future funding of makerspaces.

CONTENTS

INTRODUCTION

This paper is the final project for a Departmental Independent Study Project (DISP) at Brown University (herein referred to as "Brown" or "the University") that sought to define and examine **design**[*] as a field of study and evaluate its viability as a degree within the Brown School of Engineering (SOE). The members of this DISP are undergraduate designers from several concentrations at the University, including Independent Concentrations, Engineering, Computer Science, and Public Policy. We have a strong interest in Design and hope to centralize and increase Design resources as well as curricula. Hence, we acknowledge our biases as students with personal interests in the results of this project, and have attempted to recognize these biases throughout our research.

In creating this proposal, we iterated through the **design process**,[†] researching various aspects of Design, conducting primary research, **prototyping**,[‡] and finalizing this proposal to the School of Engineering and Brown University. First, we examined Design's history, theory, existence at Brown, as well as the aftermarket for an undergraduate Design degree to contextualize our arguments. We then moved to conducting primary research – polling high school students, Brown students, Brown faculty, faculty and students at peer institutions, and designers in industry – to inform our analysis.

RESEARCH METHODS

Before any Design curriculum adjustments could be proposed, we first needed a thorough understanding of Design and **Design Thinking**[§] and how they exist both at and beyond Brown University. Our primary goal was to understand whether having a stronger emphasis on Design would help retain students within the SOE. Our secondary goal was to understand how Design at Brown could be expanded upon for the benefit of students outside of Engineering.

Our research emphasized understanding the needs of students already interested in Design. We collected a mix of empirical and conceptual data, through literature analysis, case-studies, interviews, and surveys. The questions we addressed through this research include:

- What is design?
- What is the interest in design at Brown?
- How is design studied at Brown and other schools?
- What is the aftermarket value of a design education?
- How might design benefit Brown's School of Engineering?
- What would a design curriculum unique to Brown look like?

We began our research with weekly readings which launched a discussion and provided a common knowledge base on the above questions. These readings came in the form of journals, news articles, and books recommended by faculty and students involved in the DISP.

* The definitions of key words in this format can be found in greater detail in the glossary. See Glossary: Design
† See Glossary: Design Process
‡ See Glossary: Prototyping
§ See Glossary: Design Thinking

Once this baseline was established, the DISP members were split into five groups investigating the following five topics:

- Design at Brown - Student Perspective
- Design at Brown - Faculty Perspective
- Design at Peer Institutions
- Design After Graduation
- Proposed Design Curriculum and Courses

Each group used a combination of case-studies, surveys, and interviews to gain a thorough understanding of their focus area. The findings from these sections are explored throughout the proposal.

The research conducted for this proposal is not without limitations, however. Although best practices were followed, this research was conducted through an Independent Study and was limited at times by outreach and time constraints. The students of this DISP recommend further investigations of Design and how it could benefit Brown University that continues beyond the scope of this proposal. Despite this, we still believe that this proposal creates a valid argument for why there should be a greater emphasis on design at Brown and will be a launching point for future recommendations.

WHAT IS DESIGN?

The word “design” bears a complex and confusing history, and is used broadly to refer to **creative**[*] and technical practices across many fields. While the word does have a dictionary definition,[†] it has been abstracted through application in such a multitude of settings, and thus lost its specificity, making it heavily dependent on the context of its use. In this proposal, we conceive of design as the following:

> **Design is the action or manifestation of creation that is supported by planning or technical logic of some kind. In short, design is creation with intention.**

Although this definition is still too broad for our purposes, it does provide some fundamental ideas to our conception of this term. For example, by necessitating the act of planning or preparation, design distinguishes itself from acts of free expression. That is not to say that design does not engage with expression, rather design **must always have a constraint**. If there were not a constraint to work within, or a problem to be solved, then nothing would distinguish design from the similarly nebulous “art.” Similarly, since design is not freely expressive, it must be employed towards some end and therefore **satisfies a need**.

DESIGN PROCESS

DESIGN PRINCIPLES

ideals, standards, and “rules” of design practice
principles of creation

DESIGN THINKING

Framework for employing Design principles. “Design thinking” crystallizes the ***creation with intention*** as a mindset, a methodology for employing the set of ideals and principles which are the core tenets of “design”.

DESIGN PRACTICE

The result of Design thinking. Manifestation of labor that has been conducted using Design Thinking.
Act of Creation.

Figure 1a: Hierarchy that defines the design process.

* See Glossary: Creativity

† Webster’s Dictionary: a purpose, planning, or intention that exists or is thought to exist behind an action, fact, or material object. “Definition of Design.” Merriam-Webster, 3 Dec. 2018, https://www.merriam-webster.com/dictionary/design.

From this basis, we must delve further into the applications and phraseology of design in order to distinguish its many forms as they appear in this proposal. Design will function as an umbrella term for a related group of terms (Figure 1), which make up the entirety of the design process. Within the design process, we have the broad concept of design principles. These principles represent the ideal approach to any problem. Design thinking underlies these principles. Design thinking represents the school of thought used by designers to solve problems. Next in this hierarchy is design practice. Design practice constitutes the actual process used to create a solution to a problem. Finally, from this is problem assessment, **empathy**,* **divergent thinking**,† iteration, ethics and delivery. These six steps are key in the process of designing and producing a solution to a problem. This hierarchy outlines the terminology that is instrumental to holistically understanding the idea of Design.

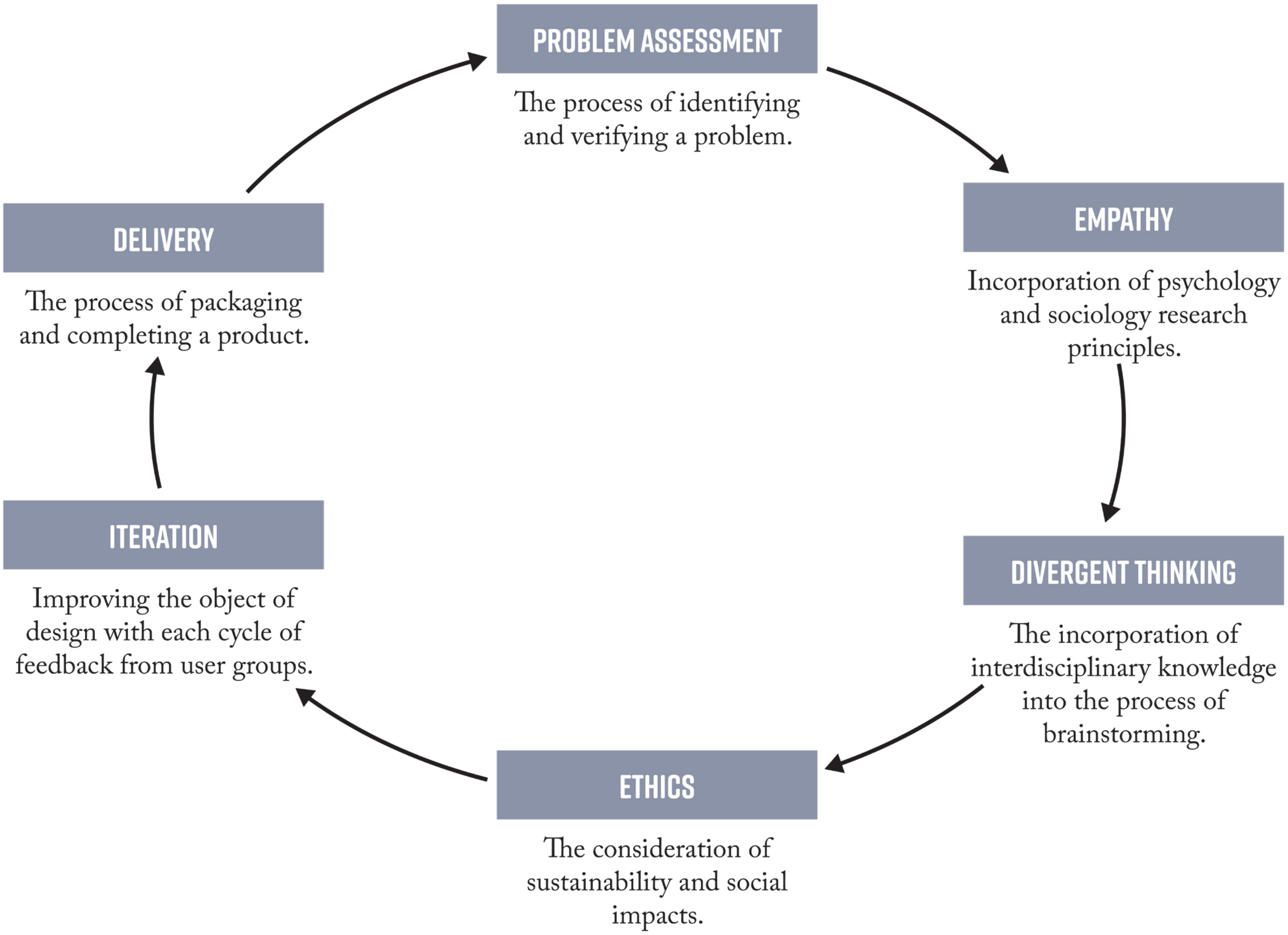


Figure 1b: Cyclical steps of design practice.

* See Glossary: Empathy

† See Glossary: Divergent Thinking

DESIGN IN HIGHER EDUCATION AND INDUSTRY

Interest in and the pursuit of Design and its subfields has been increasing over the past few years, both in academic and professional spheres. At other competitive colleges and universities in the United States, such as Dartmouth College and Northwestern University, faculty and administrative support of Design have enabled the proliferation of new design spaces, course majors, and graduate degrees.[1,2] Outside of academia, the aftermarket value of design degrees has greatly increased in recent years. At companies like IBM, for example, the ratio of designers to engineers increased from 1:72 to 1:8 between 2012 and 2017.[3]

Despite these overwhelming trends, Brown University has not yet seen sweeping change in regards to Design. Although the value of design thinking and design practice has increased remarkably, the dependency on the IC system and lack of unified Design courses at Brown has made it difficult for students to ensure that they complete a holistic design degree that prepares them well to enter the market.

WHY DESIGN AT BROWN?

In developing this proposal, we want to acknowledge this as a special opportunity to not only build a Design program but to create a Design program that is unique and specific to Brown. In that respect, our goal is to create an interdisciplinary program that emphasizes critical thinking and applications to create both breadth and depth in our students' knowledge and abilities. We broke this goal down into its primary components and explained how design is a key part of Brown's ideology.

why design is important and aligned with liberal learning

Design is inherently interdisciplinary. It is a school of thought and a method of problem-solving that is meant to be applied to any problem. If applied to the Brown curriculum formally, design will allow students to effectively contextualize their liberal arts education. Through this proposal, we hope to build an atmosphere in which design principles will allow students to approach problems with a critical and responsible thought process. It will also enable students to connect classes from different departments and programs throughout the University with the guiding principles of design to help bind them together. Design and the design process can be used as tools to approach ambiguities within different fields, "wicked"* or undefinable problems,[4] and build interventions in those areas. Current Brown faculty recognize the validity of design in a liberal education. Selim Suner, Brown UG'86 MS'87 MED'92 and professor at The Warren Alpert Medical School believes that design "promotes independent and non-traditional thought processes." Rick Fleeter, Brown UG'76 PhD'81 and engineering professor, emphasized the importance of design in education: "Design is a way of thinking. To me, it is a fundamental viewpoint from which to solve a broad range of problems across virtually all academic disciplines. To me, it is essential to education."

The breadth and depth that design enables students to cultivate serve as the same breadth and depth that are consistently cited as cornerstones of the Brown Liberal Learning Goals and open curriculum. While not always explicit, design is included in the mission of Brown as an institution, notably in its Liberal Learning Goals. Brown's mission is to serve the world by "discovering, communicating, and preserving knowledge and understanding in a spirit of free inquiry, and by educating and preparing students to discharge the offices of life with usefulness and reputation."[5]

Our proposal for a Design program supports this mission, encouraging free inquiry using design fundamentals. This breadth and depth recommended in Brown's Liberal Learning Goals is addressed in our proposal as well. At Brown, students are encouraged to be the architect of their own education where depth in one topic of interest should be complimented by

* See Glossary: Wicked Problems

a breadth of interdisciplinary knowledge that will influence their primary training. Referred to as a **T-shaped*** individual (Figure 2), a person with this education at Brown should be able to "make connections between... courses, using the perspective gained from one discipline as a window onto the next."[6]

This T-shaped model was first used during job recruiting but was popularized by IDEO CEO Tim Brown, who described a T-shaped person as having:

> **"two kinds of characteristics, hence the use of the letter 'T' to describe them. The vertical stroke of the 'T' is a depth of skill that allows them to contribute to the creative process. That can be from any number of different fields: an industrial designer, an architect, a social scientist, a business specialist or a mechanical engineer. The horizontal stroke of the 'T' is the disposition for collaboration across disciplines. It is composed of two things. First, empathy. It's important because it allows people to imagine the problem from another perspective - to stand in somebody else's shoes. Second, they tend to get very enthusiastic about other people's disciplines, to the point that they may actually start to practice them. T-shaped people have both depth and breadth in their skills."**[7]

This cross-discipline and cross-curricular model of learning is an opportunity for design to become a unique way for students to pursue academic breadth and depth. For example, with a basis in design, students can trace out their own path through different departments, identifying context-based needs and building specific field-based skills.†

Finally, we can examine design within the context of Brown's open curriculum. The timing of this proposal happens to be around the same time as the 50th anniversary of the open curriculum at Brown in 2019. When advocating for the open curriculum in 1850, President Wayland said that each student should be able to "study what he chose, all that he chose, and nothing but what he chose."[8] While this statement draws to mind the ideas of the independent concentration, this cornerstone of the Brown education falls short of achieving a robust design experience and as such, will be addressed later in this proposal.

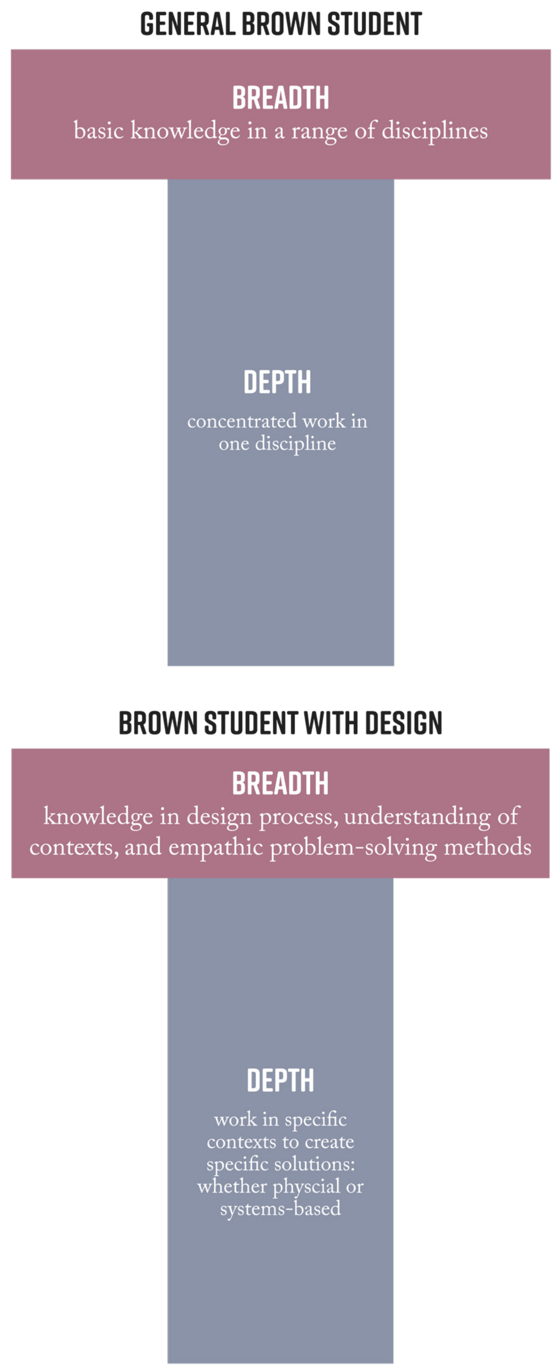


Figure 2: The T-Shaped individual is a conceptual term used to describe an individual who has both broad knowledge and specific expertise.

* See Glossary: T-shaped Individual

† For example, in Environmental Studies, that may mean examining the physical design of materials or the design of policy and programs related to environmental sustainability.

why design is important for brown's engineering department

Previously, we explained how design as an academic pursuit falls within the learning goals and mission of Brown University. We now argue why design should be incorporated and improved within the SOE. The SOE embodies the same goals as the University, seeking to develop students that synthesize knowledge and tools from different fields. Within the specific context of engineering, this synthesis should be used to understand and tackle complex problems. Engineers have been recognized as creators and problem-solvers.

However, problem-solving requires more than the theory that supports engineering principles and how to solve defined and idealized problems. It requires students to apply that knowledge in project-based learning where they must communicate with stakeholders and teammates from different disciplines and collaborate with other engineers in order to iterate different solutions to open-ended problems. These **intangible skills**[*] are fundamental to design and would better prepare engineers to undertake the reality of creating products and services in the industry. For many students in Brown's engineering program,[†] there has been too great an emphasis placed on the theory of what an engineer does and too little emphasis on how or why they do it.

design at brown and risd

In our research, students and professors alike have acknowledged Brown's proximity to the Rhode Island School of Design (RISD). This is a valid consideration as RISD is generally known to be one of the best design schools in the country. However, our vision for design at Brown is distinct from the design practiced at RISD.

RISD's approach to design is as a form of expression but does not necessitate the methodology of the design processes or stress the importance of intermediate steps in the creation of a **product**.[‡] Evidence of this can be found in the school's mission statement. The mission of RISD is to "educate its students and the public in the creation and appreciation of works of art and design, to discover and transmit knowledge and to make lasting contributions to a global society through critical thinking, scholarship, and **innovation.**"[§9] This means that RISD seeks to develop skills and practice craft, at the expense of designing to solve problems.

Furthermore, RISD students have explained that the critique (or crit) is a grading method employed by RISD that focuses on how a given piece functions in conversation with a particular art-historical background or prompt, and less on its grounding in design principles or the approach to the process of creating the work. This causes most design projects to shoot for a more "outside the box" visual style, instead of a greater focus on functionality and implementation.

In comparison, as a research institution, Brown offers design as a form of analytical engagement with creative problem-solving. As we seek to develop Brown's definition of Design, it will necessitate an understanding of the social impact of design practice and a strong interdisciplinary approach. Providing this context and understanding of the implications of design, we can build a progressive learning atmosphere with a focus on ethics and environmental considerations. Furthermore, a Brown Design program must integrate other fields of study to encourage broader divergent thinking. If Brown created a more formal structure for the study of Design, it would provide the opportunity for a deeply ingrained, multi-disciplined approach, vastly different from the pedagogy of Design at RISD. This definition of design offers an approach for a new design idealogy for Brown University in which the designer is conscious of the implications of their creation and is informed by their education, the communities it may affect, and the institutions that regulate it.

* See Glossary: Intangible Skills; Peter Robbie, Dartmouth's Design Thinking professor (see Design at Other Institutions for more), also used the term "soft" skills for what is learned in design (i.e. empathetic observation, agility in the face of ambiguity, positive response to failure, collaborative mindset).

† See research under Student Interest section.

‡ See Glossary: Product

§ See Glossary: Innovation

THE STATE OF DESIGN AT BROWN

DESIGN SPACES AND EXTRACURRICULARS

At Brown, an increasing interest* in Design has led to the development of spaces including the Brown Design Workshop, the Multimedia Labs, the List studios and the John Street Studio. These spaces serve Brown students and the Providence community, facilitating student project execution, skills development, and conversations around design. However, many of these spaces face issues with image or **accessibility**†. Upon interviewing managers of the Brown Design Workshop, they related that they are constantly trying to find ways to increase awareness of the BDW and show that it is a makerspace for everyone, not just engineers. Similarly, Multimedia Labs and the makerspace in the Rockefeller library are relatively unknown. Finally, studio spaces like John St. or List are limited to students enrolled in specific classes or concentrations. Therefore, while accessibility and capabilities of design facilities on campus have improved greatly over time, there is still room for growth.

Despite this growing interest, the lack of a central departmental structure has lead students interested in design practice to pursue most of their design opportunities outside of their education through clubs. These clubs include, but are not limited to:

- Hack@Brown
- Better World by Design
- Brown Science, Technology, Engineering, Art, and Math (STEAM)
- Design for America
- Brown Formula Racing
- Brown Entrepreneurship Program (EP)
- Innovation for Health
- Design@Brown
- Brown Space Engineering
- Brown University Human-Centered Robotics Initiative (HCRI)
- Brown Building Society

Although these clubs offer many opportunities for students who are interested in exploring design through extracurricular activities, there are disadvantages to clubs serving as the primary source of a student's Design education. Extracurriculars are a valuable part of a student's experience at Brown, but they can also require an intense amount of time that not all students can afford, due to classwork and employment. Student groups may also have a limit on size, be difficult to join or highly specialized. For instance, STEAM has recently downsized to a smaller team, Design@Brown is limited to about 10 members and Brown Formula Racing is highly specialized in vehicle creation and design.

DESIGN CLASSES

Within Brown, there are a variety of classes that explore design principles through various lenses such as business, engineering, and psychology (see Appendix-1 for related classes). These classes are instrumental to designers and are featured prominently in many independent concentrations that focus on design[10]. While we acknowledge that these classes exist, we believe that there must be a better way to integrate them into a cohesive education.

* Note an increase in design-related ICs: "IC Database" *CRC Database.* https://sites.google.com/a/brown.edu/crc-database/ic-database?pli=1. Accessed 5 Dec. 2018.

† See Glossary: Accessibility

Some of the fundamental advantages of having a wide variety of independent classes are that they range in teaching style and departmental context. Since these classes are not centralized, they are not held to a departmental theme. This means that they can offer engaging and even conflicting approaches to design that force students to think critically. For this reason, students have managed to independently compile design educations, to some effect.*[11] Unfortunately, there are drawbacks to the current system. As Brown's curriculum currently stands, there's no formal introduction to the design process. This means that Brown does not offer students a unified definition of design. Instead, students are asked to define this term for themselves, ultimately obfuscating its definition further and watering down the term Design.

Additionally, since the classes are scattered across the departments, they are difficult to identify as design classes and have no structure on which to build. This means that students must put in significant work to identify Design within the University and hope that these classes offer them the education they expect and need to become effective designers. Once students identify these classes, they still run into the issue that design is often an implicit feature of these classes. Furthermore, since there is no centralized design education, the principles of design are often tacked onto these classes as a means to an end, not a field of study. On top of this, classes operate independently of each other and therefore have no assumed knowledge. Based on our personal experience, this means that many concepts are repeated throughout classes and there is little ability to attain any deep knowledge of design.

INDEPENDENT CONCENTRATIONS

Since Brown created the Independent Concentration, it has become an outlet for students to pursue studies that are not supported by an existing department at Brown. With increasing interest in design among students, design-related ICs have become more prevalent. Independent concentrations in design spawn from design-oriented classes, student interest in the field, and broader demand for design in industry. These concentrations have ranged from **biomimicry**† to product design.[12] Students are drawn to the IC process because of the large degree of flexibility in creating a course list and the ability to tailor the concentration to be extremely specific to their interests. While these benefits allow students to create unique concentrations, the time commitment to drafting and iterating an IC proposal can be several months to a year, which makes it difficult for those students to determine course requirements, and causes others to give up the process entirely. While they are currently the best way to realize an education in design, we will later argue why independent concentrations are an acceptable short-term solution to improving design, but lack the necessities for a rigorous design education and therefore cannot survive in the long-term.

STUDENT INTEREST

The motivation for this DISP came from several passionate students who believed there was a larger unmet interest in design at Brown. However, this belief had to be confirmed through research before any arguments could be made.

methods

Our primary research method relied upon student surveys.‡ The first survey was sent out to the general undergraduate student body aimed at students who are already pursuing design in their education and extracurriculars. The second survey was sent to students who took ENGN 0030/31, "Introduction to Engineering," and ENGN 0040, "Dynamics and Vibrations" between 2015-2017. The initial survey was intended to gain a better understanding of how students pursued design at Brown and whether there was any interest in a stronger design curriculum. The second was aimed at understanding whether students who are currently declared engineering concentrators

* Deb Mills has compiled a list of students who have created ICs or studied design related concentrations and gone on to do design.
† See Glossary: Biomimicry
‡ The 27 respondents voluntarily took the survey so there is self-selection bias.

are interested in having more design opportunities in their class choices and whether students who decided not to pursue engineering would have stayed in the degree if there had been more design opportunities.

results

The survey that was sent out did confirm a lot of the initial ideas that inspired this DISP. As illustrated in Figure 3, there is a design community at Brown, with most students pursuing design within the context of classes and extracurriculars.

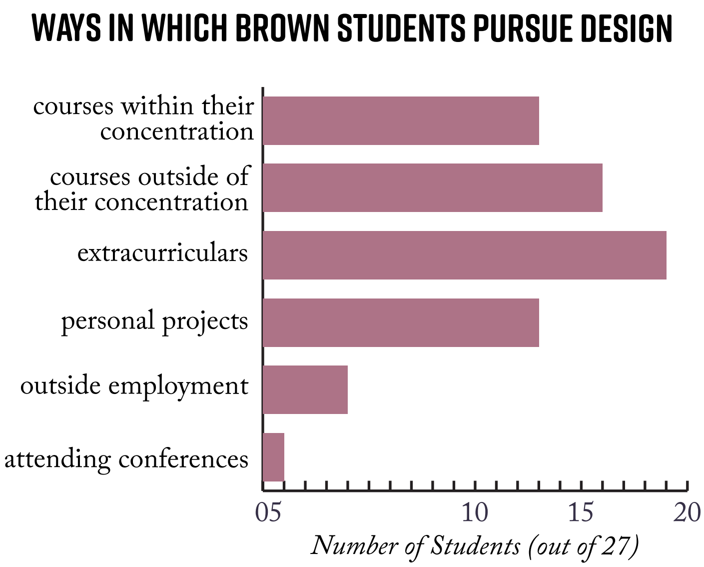


Figure 3: Graph analyzing how Brown students pursue design.

However almost all respondents said they would like more design opportunities in the form of classwork and lectures. Most respondents mentioned CSCI 1300 UI/UX, ENGN 0930C Design Studio, and ENGN 1000 as the classes that gave them the most exposure to design. Several students had specific critiques of Engineering classes as well:

> **"I believe engineering currently lacks an opportunity to practice the theory we learn and apply it in a meaningful and independent manner. While it allows extracurriculars to fill this need, I believe direction from an experienced individual would be helpful."**

> **"Engineering is too theoretical and isn't real world enough -- I don't feel like I'm getting enough experience solving real world problems."**

Additionally, almost two thirds of students also mentioned that they would like to see more employment advice on design opportunities. (Figure 4).

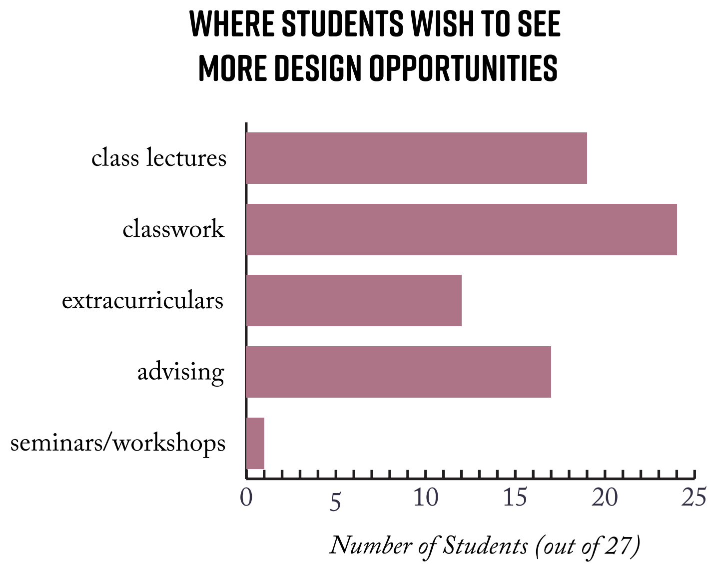


Figure 4: Graph analyzing how students wish to further learn and practice Design.

However, the most noteworthy aspect of this survey was the enthusiasm many students expressed over this survey. Many used the follow up section at the end of the survey to thank the DISP for looking more into how to expand design opportunities at Brown because it was something they themselves were upset were not available. Some of the quotes include:

> **"thank you all for doing this!!!! id be happy to help in any way - there's so much interest but a few scattered resources, yet design is so cool and important... I know I was super lost when I first wanted to learn more about this field. it shouldn't be so hard for people to come, learn, explore design!!!"**

> **"I'm someone very interested in going to graduate school in design. I was very excited to answer this survey!"**

A second survey was sent out to understand what the state of design is among students who are currently or have been in the past involved with Engineering. Of the students who responded to the survey, around 7 out of 10 were declared Engineering concentrators.

The rest were either declared in another concentration or planning on declaring Engineering as a second concentration.

STUDENTS' INTEREST IN ENGINEERING

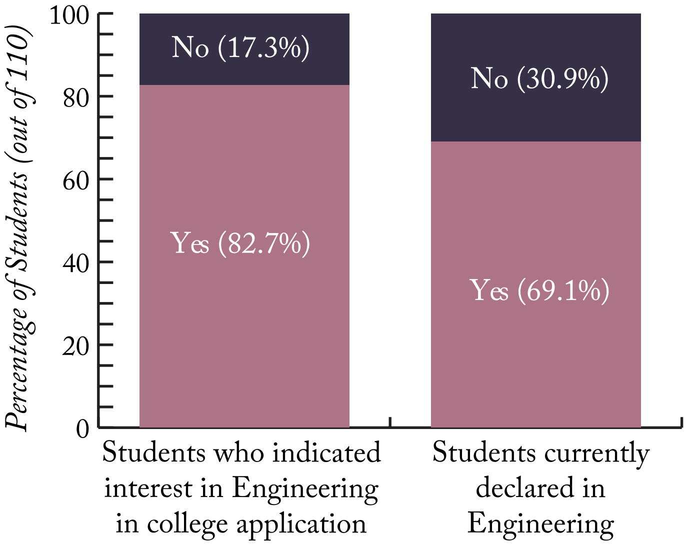


Figure 5: Analysis of the demographic of students who replied to the survey.

In order to understand how satisfaction with design within Engineering compared to other aspects of the Brown Engineering experience, we asked students a series of questions that target both design and a broad range of other issues, such as depth of material, class choices, faculty, and research opportunities. Students were asked to rank their satisfaction within each category on a scale of 1 (very unsatisfied) to 6 (very satisfied), with 3.5 resulting as the middle point for satisfaction. The averages for both Engineering concentrators and non-Engineering Concentrators were calculated for each category and plotted in Figure 6.

Interestingly enough, students outside of Engineering tended to have more favorable views of the concentration than students within Engineering, except for the categories of depth of material and research opportunities. However, both Engineering concentrators and Non-Engineering Concentrators emphasized development of student creativity as being the least satisfactory of all categories. This was then followed by application of material for Engineering Concentrators and development and use of design

LEVEL OF SATISFACTION WITH REGARD TO BROWN'S ENGINEERING CURRICULUM

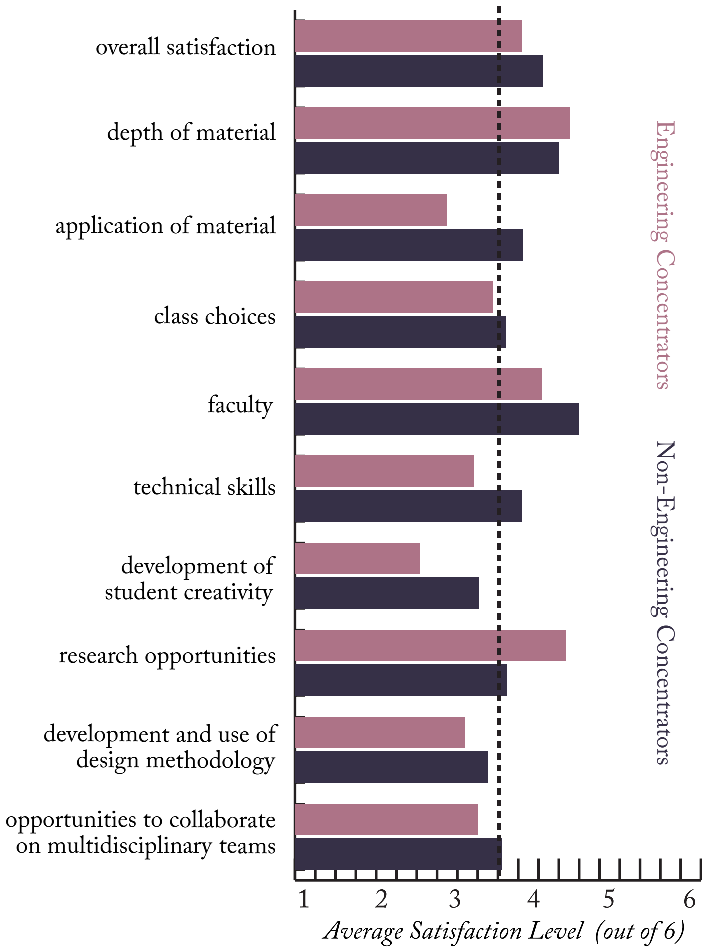


Figure 6: Analysis of students' satisfaction level within Brown's engineering curriculum.

methodology for Non-Engineering Concentrators. It is also important to note that both the development and use of design methodology, technical skills, and opportunities to collaborate on multidisciplinary teams fall below the midpoint Satisfaction Level for Engineering Concentrators.

Most students, regardless of concentration, believe that design plays a significant or very significant role in Engineering (Figure 7). However, these same students believe that Brown does not place enough significance on design in the Engineering curriculum (Figure 8). This is significant to note because this emphasis on design can play a large role in the School of Engineering's student retention rate. Of those students who left the Engineering concentration, 64.3% reported that a stronger emphasis on design would have influenced their decision to continue within Engineering rather than pursue another concentration (Figure 9).

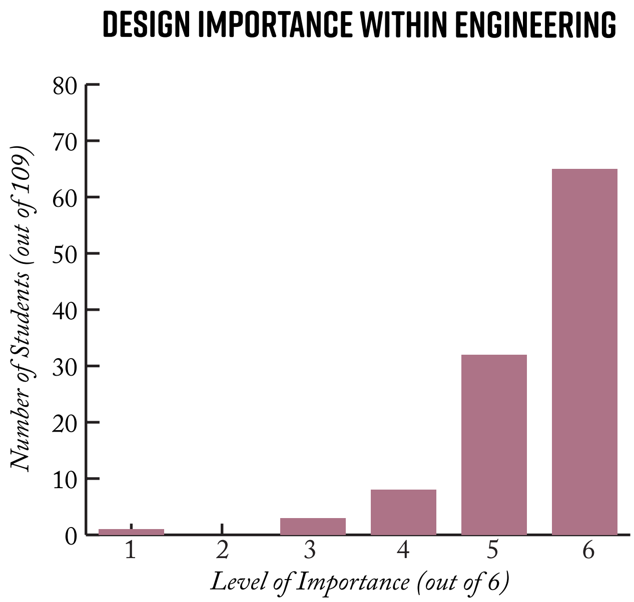


Figure 7: Analysis of students' view of design within engineering.

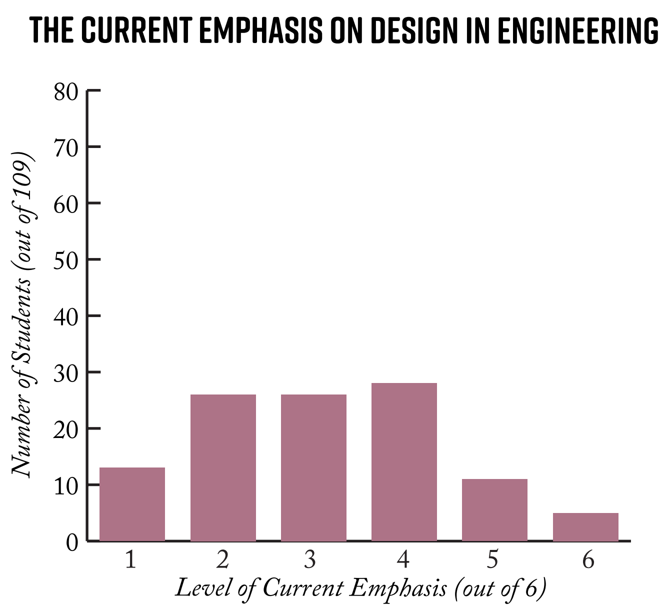


Figure 8: Analysis of students' view on the emphasis of design in engineering.

These findings are significant because they reveal how both the School of Engineering and the University as a whole are failing to address students' educational needs. Many students choose Brown over a more technical or design-focused school because of the interdisciplinary opportunities it offers. Many professors noted that students who come to Brown tend to be more driven to have an impact, and it is hard to accomplish this when

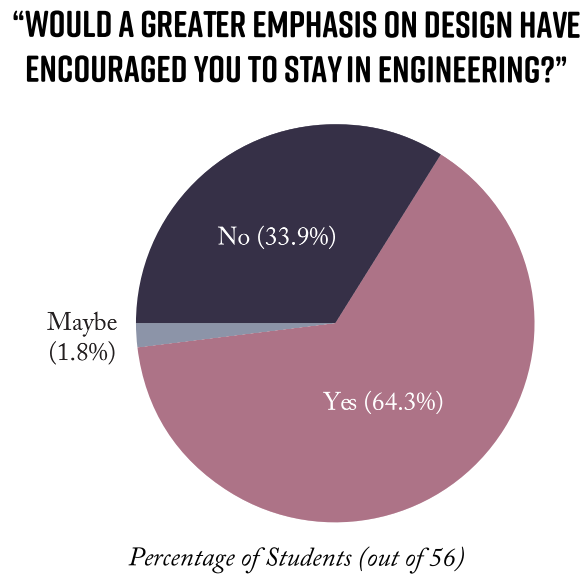


Figure 9: Analysis of question asking students if design would encourage them to stay in engineering.

classes are so heavily focused on theory. These findings help frame design as the application for knowledge that students are looking for, both within Engineering and beyond.

FACULTY AND ADMINISTRATION

In surveying Brown faculty and administration, we hoped to ascertain the perceived views regarding design in the SOE and across Brown as a whole. By informing ourselves with these opinions, we could tailor our recommendations to respond to the views and beliefs of the Brown faculty and administration.

methods

Research regarding the faculty and administration was conducted in a variety of surveys and interviews. Faculty and administration were surveyed and interviewed based upon a perceived interest in design or the results of the DISP. Separately, we emailed a survey to the entire listed staff of the SOE that asked for their:

- Definition of design
- Use of design
- Opinions on the state of design at Brown
- Inquiry into whether or not design aligns with the Engineering department's goals

From this pool of over 120 faculty members, we received responses from 41 which represented a range of opinions. We also interviewed professors, faculty, and administrators that have aided designers in the past or have a strong influence on our success. Interviewees include: Chris Bull, Paul Myoda, Ian Gonsher, Christina Paxson and Rashid Zia. The results are displayed and analyzed later in this section.

results

One fundamental question that we asked every respondent was to define "design". This question was intentionally broad, pushing respondents to critically examine their internal definitions of design and describe them appropriately. Interestingly, these responses could be bucketed off into four representative groups: design as a strategy for optimization, as a way to imbue **aesthetic*** quality, as a method of practicing engineering principles and as a school of thought. On the next page is a representative sampling of these responses.

These definitions underscore a strong divide within Brown's School of Engineering, fleshing out mentalities that we have experienced. The conflicting definitions give a scattered approach to the subject matter itself: should a designer focus on form by improving aesthetic quality, function by optimizing its usage, or even probe what it means to be a designer and the ethics behind it? One can argue that all three should be employed if one seeks to become a well-rounded designer.

Following this question, we asked faculty how often they used design in their everyday work. Perhaps not surprisingly, faculty suggested that they design quite often. On a scale of 1 (Almost Never) to 5 (Often), most faculty responded that they design over half the time (3 or above). Results, which are displayed in Figure 10, suggest that design is an important part of professors lives either as lecturers or as independent researchers. This leads one to wonder why we don't teach such a relevant subject.

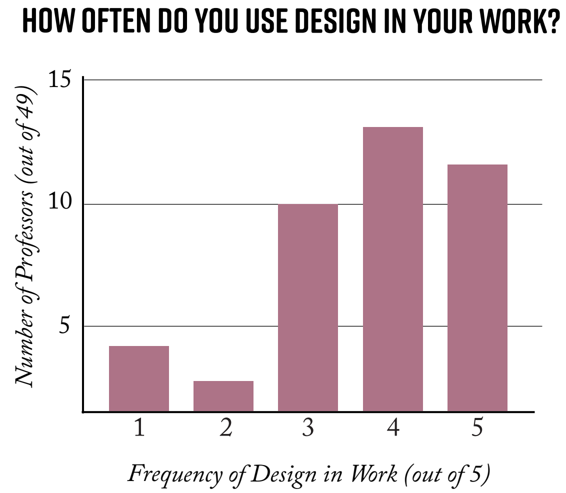


Figure 10: Graphic analyzing how often professors asses they use design in their daily life.

In light of the varied definitions of design, these results are muddied. Every faculty member self-defined design (Table 4) and while they agree that they practice, we wonder how often these faculty would agree that they use design if it had a set definition that blended all of these themes? While these questions could be better tuned for precise answers, they help illustrate the issues students who seek to become designers face.

Another key aspect of this DISP was determining which department may serve as a home for a more formalized study of design. Because roughly half of the students in the DISP study engineering and because design is housed in engineering departments at other institutions, we reasoned that the SOE would be a good fit. To test this hypothesis we set out to determine the following:

- Are the fields design and engineering complementary?
- Is the study of design well-integrated with the current engineering curriculum?
- Does a BA in Design have a place in the SOE?

At the outset, our DISP as a whole would say that design complements engineering, the study of design is poorly integrated into engineering, and that a Bachelor's of Arts in Design could have a place in the SOE. Yet these opinions were largely informed by our own experiences. Rather than find outside research to support these opinions, we decided to survey the faculty

* See Glossary: Aesthetics

DEFINITIONS OF DESIGN

Design is a strategy to optimize a solution, within constraints.	**"It's pretty"**	**Design is a way to apply Engineering principles to practice.**	**School of Thought**
Finding an (optimal) solution to stated problem with a given set of constraints through an iterative process of trial and error. - **Brian Burke**	Aesthetically pleasing and useful engineering, usually for human use - **Chris Rose**	Solve for specs in an open-ended environment, where many 'designs' seem possible. To the beginner there are many possibilities; to the expert there are few. Design involves planning and should be distinguished from tinkering or trial and error work... of hobbyists and "inventors" chasing patents… - **JD Daniels**	Design is a way of thinking. To me it is a fundamental viewpoint from which to solve a broad range of problems across virtually all academic disciplines. To me it is essential to education. - **Rick Fleeter**
A set of parameters that are manipulated (and eventually optimized) in an operational space whose perimeter is dictated by constraints in order to meet one or more end goal(s). - **Sharvan Kumar**	Using raw materials to assemble something of aesthetic or practical value - **Daniel Harris**	Coming up with a practical, economical, simplest possible and manufacturable/implementable solution to an engineering problem. - **Pradeep Guduru**	Design promotes independent and non-traditional thought process - **Selim Suner**
I define design as the use of physical science, mathematics and computation to conceive or optimize a system to meet a well defined (quantifiable and measurable) technical objective. - **Allan Bower**	Develop a functional and pleasing form for an object - **Martin Maxey**	I think what most people in the outside world think of when they see the word design (e.g. graphic design) is the process of fine-tuning the appearance of a product in order to make it sell. Others might say it is the process of inventing a product or service that improves people's lives - **Allan Bower**	
Achievement of successful solutions to actual practical problems within limits of cost and time. - **Peter Richardson**	Making something effective and attractive - **Barrett Hazeltine**	Design helps students see how to use all they have learned to solve problems and helps develop that problem solving skill set. It is a way to tie their education together. - **Raymond Roberts**	
The process of creating artifacts or processes that satisfy a set of conflicting constraints. - **Michael Littman**		Design might serve to connect engineering and making to the world of people, and the liberal arts is what helps us understand that world. - **Steven Lubar**	

Table 1: Table displaying conflicting definitions of design presented by Brown University faculty.

to determine if the study of design should be housed in the SOE. This brought us outside of our little "bubble of design."

The survey revealed that generally, faculty believe the engineering department would benefit from a more rigorous study of design. Overall, design is viewed as a field that is complementary to Engineering.

Design Complements Engineering

What is engineering? Making things that have not existed before. How can you do that without design? What else is in engineering? Analysis, which is increasingly a commodity, as are 'making.' Design in the broader sense of a mode of thought is the main value add of students from Brown over engineers to whom most of the rest of engineering can be outsourced**. I believe design is the future of Brown engineering.** - **Rick Fleeter**

Some research would benefit from closely working with design concentrators. - **Jonghwan Lee**

In the engineering field, I believe that design courses do two things. First, it can be used to introduce students to open ended problems with poor specifications, much like what the real world is like. Second, to helps students see how to use all they have learned to solve problems and helps develop that problem solving skill set. It is a way to tie their education together.
- **Raymond Roberts**

Design is an integral part of all engineering. It should not be separated into yet another concentration. - **Jingming Xu**

Design is one of the foundations of engineering.
- **Domenico Pacifici**

Design is a natural fit with engineering. - **Daniel Harris**

Design Does Not Complement Engineering

Personally, I don't think it is analytical enough (i.e., mathematical) to be part of the Engineering curriculum. - **Eric Chason**

Table 2: Table comparing faculty opinions on whether design complements engineering.

We next asked if faculty believe that design is well-integrated into the School of Engineering. Faculty pointed out that while design is scarcely taught in courses, it can be explored through extracurriculars and at the BDW.

Design Is Well-Integrated Into Engineering

The Brown engineering students seem to be doing a great job in picking up design on their own through the existing curriculum and mentorship of some faculty. It is not structured but Brown engineering offers a lot of opportunities for students to hone their design skills.
- **Pradeep Guduru**

Design Is Poorly Integrated In Engineering

Design is not formally taught as part of the regular Engineering curriculum, so I would consider this a weakness.
- **Ruth Bahar**

I think we are very strong in encouraging our students to be creative and innovative (these are essential features of good design). But we don't give them enough experience in design in our classes, and "creation" is not an explicit goal of the traditional conception of the liberal arts degree.
- **Larry Larson**

The state of design is "Weak. Only EN163 or EN123 meet my idea of design in Brown Engineering. ha ha! both were created/re-created by me... courses by Patterson are good too.
- **JD Daniels**

Table 3: Table comparing faculty opinions on how design is integrated into Engineering.

Brian Burke took a neutral stance. His response best encompassed the overall sentiment of the faculty:

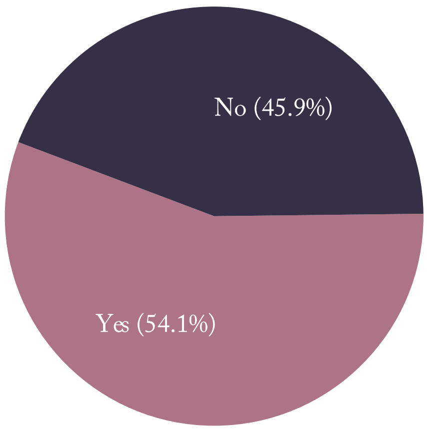
> **"Design is not a primary focus of the curriculum and this is a double edge sword. My view on Brown Engineering's focus on theory is that it is a good thing. The opportunity to put such an intense focus on theory is not afforded to engineers at any other time in their career. The trade-off at times is that design is a secondary effort. However, I have found that the students who push for additional opportunities to practice design do find opportunities to do so."**

DEFINITIONS OF DESIGN

Yes	Maybe	No
A high quality design program could strengthen the link of Brown engineering to industry and make it more attractive to students. **- Huajian Gao**	Certainly. I'm not sure how it would fit in within Brown's SOE, but I think more education and research into good design can only be a good thing. **- Franklin Goldsmith**	We have RISD nearby. Having a selection of related courses would suffice. Design of itself would be too narrow for a Brown concentration. **- Jason Gaudette**
Perhaps a Bachelor of Arts degree in design can combine some of the entrepreneurship and STEM classes with a focus on allowing students to practice design through extensive, interactive prototyping. Maybe combining with 1-2 RISD design classes also makes sense? **- Steven Petteruti**	In general Design in Engineering is a good idea as most engineering discipline have design in them. The challenge is that separating it out may broaden the scope so much that the required depth in any one field of design will be lost. **- Vikas Srivastava**	I think that I would rather see more design integrated into engineering and other concentrations than added as a separate thing. I think there are lots of silos for design at Brown, RISD, in Providence, etc, but they aren't working effectively together. I'm not sure that adding another player to the mix will facilitating connecting what's already here. **- Celinda Kofron**
Traditional role of engineers was to make things. We seem to have gotten away from that attitude. A BA in design would reaffirm the importance of making things well. **- Barrett Hazeltine**		Design only makes sense when there is pressure to create. Having fluffy lectures about brainstorming or prototyping or product testing, or PERT charts is of little value. **- JD Daniels**

Table 4: Table analyzing if BA in design belongs in the School of Engineering.

"DOES A BA IN DESIGN HAVE A PLACE IN THE ENGINEERING DEPARTMENT?"



Percentage of Professors (out of 39)

Figure 11: Graph analyzing faculty opinion on if a BA in design belongs in the Engineering department.

Lastly, we outright asked, "Does a BA in design have a place in the School of Engineering?"

Design in the engineering department is a tricky proposition. In many respects, the department's faculty are split on the idea of a design Bachelor's of Arts (BA) degree. Generally, professors are design-friendly. They see value in design and believe that design is well-represented in extracurriculars. However, while faculty often use design skills and recognize its value, they do not feel strongly enough to make a pedagogical or departmental shift. However, professors, including Derek Stein and Ruth Bahar, acknowledge that design is poorly integrated into the engineering curriculum.*† There are certainly voices of support within the School of Engineering. With that said, it is not overwhelmingly apparent that there should be a design degree under the School of Engineering.

* "Design principles are used in a variety of projects thanks to the natural tendency of Brown students and faculty to think in ways that cut across disciplines, but there is very little in the way of formal teaching or application of design." - Derek Stein

† "Design is not formally taught as part of the regular Engineering curriculum, so I would consider this a weakness. Our strength is the accessibility of different disciplines by students and faculty for input/expertise in various aspects of the design process. Another strength in the BDW" - Ruth Bahar

PAST ATTEMPTS AT DESIGN AT BROWN

There has been interest from both students and faculty in the creation of a stronger design education at Brown for many years. A few of Brown's current clubs and groups were formed on the basis of this interest. Thirteen years ago, Brown Engineering students and RISD students interested in the intersections and collaborations of design between the two institutions and the world founded Better World by Design, an annual design conference.[13]

The second push for more design-related curricula came in 2014 when students and faculty met for a period of a few months and drafted "The Case for Design," a document which outlined reasons why design should be offered at Brown*. This effort was lead by both faculty and students, however it failed to invoke change because it did not set forth a rigorous enough definition of design and how it can be studied at a research institution.[14]

Another important aspect of design education at Brown is the creation of Independent Concentrations in these areas. This has been the only option for students interested in the field of design to learn the fundamentals of design principles and process. From 2002 to 2018, there have been 18 Independent Concentrations related to design, including Biologically-Inspired Design, Social Innovation, and Visual Perception and Art.[15] These do not include Independent Concentrations in design for current undergraduates, which include Product Design and Human-Centered Design.

* Some of these arguments are made in this paper as well. The link to this document can be found here: https://docs.google.com/document/d/1WS3Fv2ZJpIyhKlbHn69uypU1DmFDJMTluY-DWzijskg/edit?usp=sharing

DESIGN AT OTHER INSTITUTIONS

Design education is no longer reserved for art or design schools. Many liberal arts universities and colleges, including many of our peer institutions, offer design in their curricula. Most of these programs were established in the last 20 years, and many were created even more recently as a greater number of institutions are recognizing the importance of integrating design with traditional academics in order to create students ready to tackle ill-defined problems. To understand what already exists in undergraduate design education, specifically as it overlaps with engineering, and to understand how Brown might position itself uniquely from these institutions, we researched other universities that offer design.

PRELIMINARY RESEARCH

We started with a broad mix of institutions chosen either for their exemplary design programs, unique engineering programs that emphasize design, or because they are design programs at peer institutions. The design schools we have chosen are Stanford University, Dartmouth College, Northwestern University, Olin College, Carnegie Mellon University, Cornell University, University of California Berkeley, Tufts University, and Massachusetts Institute of Technology. These schools are only a fraction of the number of design-related degrees that exist in the U.S., the table on the next page summarizes the types of design pursuits available in each school.

As a group, we ascertained how these schools have been successful or unsuccessful in pioneering their respective design programs in the hopes that we might replicate their successes in a method that is context-specific and beneficial to Brown. Since we had limited time and resources, we left our preliminary research to focus on a few schools whose design offerings were 1) related to their engineering programs and 2) schools considered to be our peers in liberal education, structure and research emphasis.

The three schools that best fit these two constraints were Stanford, Northwestern, and Dartmouth. Once we had narrowed down these schools, we reached out to students and faculty to understand the strengths, the weaknesses, and the history of their programs. We will talk more in-depth about our findings on these three programs in the next sections.

methods

The strategy we took to do our research was:

PRELIMINARY RESEARCH

Researched all the schools on our list by going on websites and talking with friends attending these schools to understand:

- How is design manifested in the curricula? (department, major, minor, other?)
- Examine classes (general design and specific to engineering)
    - Project based or theory based?
    - How much real world emphasis?
- What department does design fall under (is it interdisciplinary)?
- Is there a makerspace? What is the role of the makerspace?
    - How does it fit within the larger school?
    - Who's permitted to use it?
    - How do you apply? How are people set up incorporate or not incorporate it into their degree?

↓

REFINE OUR LIST

Refined our list to schools that both

- have a great design program and/or engineering design program
- were comparable to Brown in liberal education, structure and research emphasis

↓

CONTACT PROFESSORS AND STUDENTS

Contact students and professors at these institutions to understand:

- What would you consider the most successful aspect of your design program?
- What are the weaknesses to your design program?
- What is the experience of student/faculty in this program?
    - What kind of support do they have?
    - What value do they see in this program?

Figure 12: Flow chart showing the research methods for investigating design at other institutions.

DESIGN DEGREES AT OTHER INSTITUTIONS

School	Name of design pursuit	Degree type
Carnegie Mellon University	Bachelor in Design within their own design school. Three tracks for specialization: Products (industrial design) Communications (graphic design) Environments (both physical and digital)	Bachelor in Design Interdisciplinary Minor in Design Dual Degree (BXA -- Design+ Humanities/-Science) IDeATe (Integrative Design, Arts, and Technology Network)
Cornell University	Design and Environmental Analysis (D+EA)	Bachelor of Arts
Dartmouth College	Minor in Human-Centered Design	Minor
Massachusetts Institute of Technology	Design Lab or Senior Thesis	N/A
Northwestern University	MaDE (B.S and ABET accredited) Segal Design Certificate MIES (Integrated Engineering Studies)	Bachelor of Science or Certificate
Olin College	Design Lab or Senior Thesis	N/A
Stanford University	Product Design (within school of engineering)	Bachelor of Science
Tufts University	Human Factors Engineering (within school of engineering)	Bachelor of Science
University of California Berkeley	Jacobs Design Institute	N/A

Table 5: Table displaying some of the design degrees from across the country and their official degree type.

DESIGN AT STANFORD

Known as one of the pioneers in design education, Stanford has a host of resources, teachers, and programs that incorporate design practice and design thinking into the traditional liberal arts education. The most well known of these resources is the d.school; however since we focused our research on undergraduate offerings, we only focused on the Product Design major in Stanford's undergraduate engineering department.

The Product Design (PD) major[16] is a Bachelor of Science degree that focuses on design engineering. This program has existed for a relatively short amount of time at Stanford and has been reworked in the last couple of years as the program has grown. Students must take the core engineering requirements for all engineers in their first two years and then complete their PD track-specific core classes their sophomore, junior, and senior year. The subjects that make up their core engineering requirements include math classes, science classes (half of which are physics and the other which are psychology), and engineering fundamentals (statics, computer science, electrical engineering, materials, and solid mechanics). The PD core classes consist of a class where design fundamentals are explored to develop learning tools and strategies to execute the design process.

Product Design Degree Requirements

Engineering Core
- 4 Math courses
- 4 Science courses (1 in Physics and 1 in other, 2 in Psychology)
- 2 Engineering fundamentals (1 in Electronics and the other in CS)

PD Track Core
- 14 courses
- Specific intro engineering subjects related to PD
- Manufacturing and creation
- Design process and visualization classes

Other
- Two computer science or studio art courses

Figure 13: Figure showing product design requirements for Stanford product design degree.[17]

Two classes that are representative of the PD core are ME102 Foundation of Product Realization/ME103 Product Realization: Designing and Making and ME115A Introduction to Human Values in Design. These are both classes taken by Juniors in PD. A detailed description of these classes can be found in the Appendix-2.

A weakness of this program, however, is its lack of an introductory design principles class that is geared towards younger students and is open to students in other departments. Almost all of the classes that PD students take in their freshman and sophomore year are engineering heavy and they do not have access to PD specific classes until later in their time at Stanford. This can make it difficult for students to initially see how Design and Engineering can be combined. Another problem with the PD program and the design-oriented classes that are offered are that they are only available to engineering students. Design-interested students from other disciplines are unable to take PD classes, keeping the knowledge of design exclusively for engineers. Brown can capitalize on these two weaknesses and create an introductory design principles course geared towards freshmen and sophomores that allows students an introductory to the design process and principles.

DESIGN AT NORTHWESTERN

Design is deeply embedded within Northwestern, most significantly within the McCormick School of Engineering and the Segal Design Institute. Design pedagogy permeates the 'Design Thinking and Communication' (DTC) requirement in its Engineering First curriculum, the MaDE. (Manufacturing and Design Engineering) degree, the Segal Design Certificate, and the MIES (McCormick Integrated Engineering Studies) degree. Northwestern's approach is described as the 'whole-brain' approach[*], where whole-brain engineering refers to the combined development of analytical left-brain skills and creative right-brain thinking abilities.[†]

* See Glossary: Whole-brain Thinking.

† It has been repeatedly proven that the idea of a left and right brain is in fact a stereotype;

design thinking and communication (DTC)[18]

In terms of an engineering core, Northwestern has 8 distribution area, with design thinking and communication being 1 area comprising of 3 units.

To ensure that all engineering students have early exposure to concepts in design thinking and human-centered design, Northwestern's Engineering First program was designed specifically for freshmen and features two integrated course sequences: Engineering Analysis (EA) and Design Thinking and Communication (DTC). In their first year, all engineering students at McCormick are immersed in design in these core classes and have the added advantage of informal lectures that complement their learning. In these lectures, representatives from industry or invited speakers are regularly featured to expose students to the implications of engineering and design beyond the classroom. Involving faculty from both engineering and the Weinberg College of Arts and Sciences, DTC courses aim to pursue an interdisciplinary approach that has been recognized as a model in innovative education.

DTC courses teach theory and practice concurrently, immediately putting students to work on real design problems submitted by non-profit organizations, industry members and entrepreneurs. For example, in the first quarter of their freshman year, students are expected to work with the Rehabilitation Institute to design for the disabled. This exposes students to the social impacts of engineering early on, allowing them to become empathetic individuals and communicators. To ensure a team-based approach, students are randomly placed in groups of 4 with a mix of skill sets. This is done intentionally so students can overcome the differences in backgrounds and outlooks, which is "crucial to successful design work."[19] DTC aims to teach students that design and communication are iterative, context-centered, problem-solving processes, that "a key component of the design process is the cultivation of empathy, reflecting the need for designers to step outside their own perspectives and understand the true needs of the end-user."[20] DTC students also get to use the Prototyping and Fabrication Lab and all facilities associated with the Farley Center for Entrepreneurship and Innovation.

manufacturing and design engineering (MaDE BSc)[21]

MaDE aims to educate engineers on all aspects of product realization, from product design to manufacturing technologies and operations. Beyond a product design approach, MaDE also aims to promote systems thinking* by teaching students how to integrate various design and manufacturing processes into an effective system. As an ABET-accredited major, MaDE is based on the objectives that manufacturing and design is an interdisciplinary field, that hands-on experience is required, and that a balanced emphasis on the 'design', the 'process, and the 'systems' view of manufacturing is essential. After the Engineering First curriculum in their freshman year, students specialize in more specific focus areas. In their senior year, students have the opportunity to design a capstone around a given prompt which requires them to take a product from sketch to patent level.[22]

mccormick integrated engineering studies (MIES)[23]

In addition to MaDE, Northwestern has an integrated engineering studies program MIES (McCormick Integrated Engineering Studies) that gives students the opportunity to develop an individualized engineering degree program. This was done out of recognition that "increasingly, key advances in both engineering science and its applications occur at or beyond traditional boundaries, at the intersections between engineering fields, and between engineering and other areas of expertise."[24] Some examples have been "Mechatronics and User Interaction in Design Engineering", or

Nielsen, Jared A. et al. An Evaluation of the Left-Brain vs. Right-Brain Hypothesis with Resting State Functional Connectivity Magnetic Resonance Imaging. [online] Published: August 14, 2013 https://doi.org/10.1371/journal.pone.007127. [Accessed 3 Dec. 2018].

* See Glossary: Systems Thinking

"Technology and Design for the Arts."

segal design certificate[25]

The Segal Design Certificate is a certificate that comprises a set of courses and projects that build design knowledge and skills. It is available to any undergraduate at Northwestern interested in gaining a competitive edge in their professional career. Working in team-based, cross-disciplinary settings, students pursuing the certificate focus on innovative design processes to solve real problems for real clients.

Considering the differences between Brown and Northwestern is imperative to understand curricular differences and highlight opportunities that are yet to be trialed at Brown. Since the 1990s[26], when the Dean of Engineering at Northwestern and six to eight other key faculty championed Design to be embedded in the engineering core and the larger university, Design has been a priority in developing the Engineering First framework, the senior capstone, and the upper-level classes that are offered in students' sophomore and junior years. For those interested in doing Design at Brown, they are usually asked to do an Independent Concentration. Without past coursework (with exceptions from high school or gap years), an existing design professor, or an introduction-level design class, students are left to review past IC proposals to not only understand design but define design for themselves.

The existence of MIES (Integrated Engineering Studies) at Northwestern has demonstrated that offering MIES in addition to having a popular MaDE program is possible within the School of Engineering. In parallel to Brown, offering a Design program whilst leaving the option open for students who might do an Independent Concentration could be complementary.

Both MaDE and the certificate are housed within the Segal Design Institute, where MaDE serves as an engineering design degree whilst the certificate is open to all Northwestern students. Those looking to earn a certificate want to learn certain design knowledge and skills, but would still like the option of majoring in their respective fields. Similarly, students at Brown should not have to choose between an Independent Concentration and their concentration of interest to engage academically in Design. Though there is the option of double concentrating, the rigor and time-consuming nature of the Independent Concentration makes double concentrating very difficult and prevents a student from maximizing the flexibility of the Open Curriculum.

DESIGN AT DARTMOUTH

Design at Dartmouth exists in the curriculum as a minor in **Human Centered Design***. This minor is offered and supported within the Thayer School of Engineering. Students are required to take a total of six courses, two of which are required classes and four of which are classes that can be chosen from a pre-approved list. These six classes fall under 3 categories:[27]

1. Design Foundation ("Design Thinking" and "Introduction to Engineering")
2. Ethnographic Methods and Human Factors (two total classes), and
3. Design Electives (two courses, chosen from classes ranging from Engineering to Public Policy to Architecture).

This minor is taken by students in engineering and non-engineering. We interviewed students majoring in Economics and Asian & Middle Eastern Studies who did a minor in Human Centered Design).[28,29,30]

The history of how the Human Centered Design (HCD) minor came to exists at Dartmouth starts with Professor Peter Robbie who started teaching his introductory course, "Design Thinking," almost 30 years ago. The popularity of that course was and is still immense, with every student we talked to applauding it as one of the most popular classes offered at Dartmouth. It is offered every term and has extended to two sections per trimester, with approximately 25 students per section, only 20% of which are engineers.[31] Design Thinking is, as Peter Robbie put it, a "course in creative

* See Glossary: Human Centered Design

strategies in human-centered design" which is meant to be an introduction to the design process and to inspire creative agency in students from all disciplines. As this course gained more and more popularity and other professors became interested in design education (in fields such as computer science, architecture, and engineering), there became interest in creating a minor which was first offered to students in 2014.[32] Over ten weeks, students engage in six interactive projects, the first focused focus on skills: ethnographic observation, acknowledging constraints, graphic design software, and modeling with foam core. The latter three use the full design process for product design, digital design, and a final project focused on improving a problem at Dartmouth.

It was essential for us to understand how our Ivy League peer institutions teach Design and specifically how they were expanding it within their engineering departments. Dartmouth is one of two of the Ivys that offer non-architectural design programs (the other is Cornell, which has a program called Design and Environmental Analysis within their College of Human Ecology. We thought that this program while interesting in its offered classes and its mission, was less helpful to us as a model because it housed Design within a non-engineering department). Dartmouth's model is very reminiscent of the way that Stanford's engineering design program is set up. However, at Dartmouth, the human behavior and design classes are still separate from the engineering. This separation of the Human Centered Design and engineering makes it so that students from any major can get a HCD minor and incorporate the practice and principles of design into their education, however, it also doesn't explicitly put the emphasis of Design in the engineering curriculum. These two points are the largest strength and largest weakness of the structure of Dartmouth's program. When considering the future of design education at Brown, we want to capture the availability and applicability that the design minor affords but also promote a greater emphasis on design in engineering education.

HOW THESE SCHOOLS DIFFER FROM BROWN

Brown has qualitative and pedagogical differences in comparison to the schools examined that are crucial in studying the implications of Design at Brown. Despite having similar student body sizes, Brown's curriculum is still arguably the most flexible in terms of requirements and approaches to learning, followed by Stanford, Dartmouth, and Northwestern. With regards to the growing trend in design offerings at colleges across the U.S., Brown stands to benefit in offering another way to engage academically in Design in addition to the Independent Concentration. While we recognize that students can register for classes at RISD, Design as taught at RISD is focused on the practice of specific crafts (eg. graphic, furniture, architecture, et cetera), as supposed to learning engineering and design in tandem with one another, or learning the overarching principles and pedagogies of design itself.

Brown has the opportunity to build an innovative design program through the diversity and flexibility of the Open Curriculum. For example, this potential design program can draw on the strength of faculty from across the University, as McCormick (SOE) at Northwestern partners with the Weinberg College of Arts and Sciences to provide faculty members that teach writing and communication. As such, Brown stands to offer Design as a catalyst that mobilizes and maximizes the flexibility of a liberal arts education with a comprehensive engineering program. Further research and collaboration with these schools would be crucial in possibly spearheading a Design program at Brown.

INDUSTRY AND AFTERMARKET

The purpose of this section is to analyze how the current industry views and incorporates design into its everyday practices and projects; by doing so, we will gain a more thorough understanding of the requisite skills a Brown University student will need to bring to the table to be a strong, successful candidate in any Design related field post-graduation.

We have researched a multitude of companies, varying deeply in their market offerings and business propositions. Some of these enterprises are industry leaders in their respective fields, such as the automotive and fashion industries Others still are design firms, a workplace specifically for designers engaged in conceiving, designing, and developing new products, experiences, or systems.

Although all these to-be-mentioned firms may serve a distinctive niche or purpose within the constructs of the general world market, all ultimately seek out designers in one shape or another to help bring their intended products, services, or experiences to the masses. This section explores explicitly both what opportunities exist for students wishing to pursue Design at a post-graduate level, in addition to the specific requirements firms look for in candidates when going through the hiring process.

METHODS

To get a tangible grasp of the aftermarket, we contacted employers from various companies, including Brown alumni, and surveyed their responses about design-centered roles and the field as a whole. These employers included IDEO, Betchtel, and McMaster-Carr. We generally sought to answer these questions:

- What was their educational background?
- How did their education help them in their current or past position(s)?
- What they believe is crucial in becoming a successful designer?
- What skills they would seek if they were to hire someone in their position/department/company?

In addition, we analyzed more than fifty job postings to gauge the most sought out skills sets companies looked for in their applicants. This was aided by the use of Voyant Tools, an open-source, web-based application that performs text analysis uploaded by the user, which, in this case, included the summary, responsibilities, requirements, and, if available, reviews of the posted positions. We ultimately supplemented our observations with research findings from articles or studies performed by individuals, including Lockheed Fellow Leland M. Nicolai and Auburn University Assistant Professor Tsai Lu Liu, who examined the industries view of design. This research primarily delved into two key areas: (1) design within engineering curriculums nationally, and (2) the skills required to successfully design.

RESULTS

demand for designers

Design is one of the most in-demand fields in the market.[33] The skill set of a designer is necessary in almost every business, especially since product and systems design* is becoming more essential in recent years. After graduation, students who studied design in their undergraduate program either go to graduate school or work for a firm as a full-time employee or an independent contractor. The following list includes statistics that demonstrate the growing presence of designers in industries:

- According to a Labour Force Survey conducted by the Office of National Statistics, 40% of professional freelancers are in design and media, and from our observations across companies, most students end up working for technological, design, or consulting

* See Glossary: Systems Design

firms, and they are in high demand.[34]

- The Creative Group released a 2018 guide revealing that 45% of executives expressed a need for skilled creative professionals[35]
- Technology giants like Facebook, Google, and Amazon have collectively grown art and design headcount by 65% in the past year. [36]
- Design is also incorporating a blend of engineering as computational designers remain in demand at technology companies of all sizes and maturity levels. Companies like Atlassian have gone from a ratio of one designer to 25 engineers in 2012 to one designer to 9 developers in 2017. Figure 14 highlights the increasing market just within the last decade.[37]

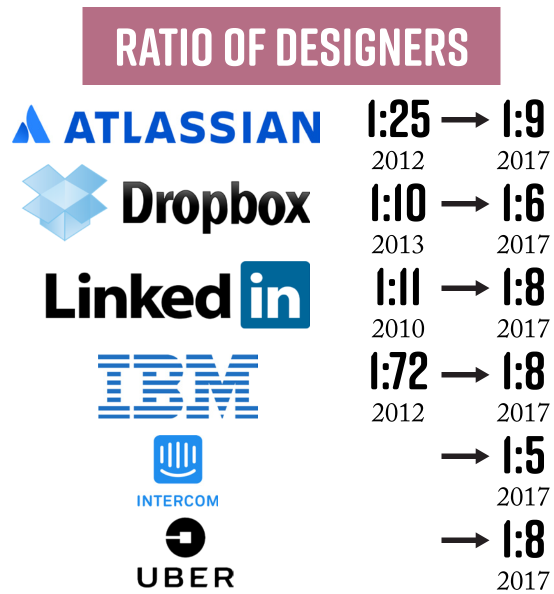


Figure 14: Increasing ratio of designer to engineer at Atlassian, Dropbox, Intercom, Linkedin, Uber, and IBM.

skills

Of the 51 job postings explored, some of which are listed below, roughly 23 sought applicants with engineering-design backgrounds. The requirements and job descriptions for general design industries and for engineering-design are listed separately since there were distinct prerequisites that stood out when engineering roles were examined. The skills commonly demanded by these companies in various design roles are explained by Leland M. Nicolai in her paper "Viewpoint: An Industry View of Engineering Design Education"[38] and are summarized in Table 6, while those specifically sought out within an engineering-design role are summarized in Table 7.

TANGIBLE SKILLS	INTANGIBLE SKILLS
• software (CAD/CAM, Fusion360, SolidWorks) • fundamental grasp of math and sciences • perform trade studies • sketching/descriptive geometry • understanding of kinematics • understanding of statistics • understanding of economics • materials and processes/manufacturing • basic coding skills • user research techniques • data visualization	• creativity • communication (writing, speaking) • team work • initiative • transition between deductive/analytical and associative/creative

Table 6: Common skills sought from applicants in engineering-design roles

TANGIBLE SKILLS	INTANGIBLE SKILLS
• portfolio • software (CAD, Adobe, Rhino) • sketching • data visualization • architecture • typography	• creativity • communication (writing, speaking) • team work • initiative • transition between deductive/analytical and associative/creative

Table 7: Common skills sought from applicants across other design roles

The following comprise some of the companies investigated:

- IDEO
- Porsche
- Dassault
- Bechtel
- McMaster-Carr
- FCA
- Reebok
- Kelloggs
- Frog
- Nike
- Adidas
- Pininfarina
- Designworks
- Microsoft
- Luminary Labs
- Asana

There is an evident overlap between the **intangible skills*** required of most design jobs, including those that are engineering-specific. As Table 7 illustrates, all design jobs usually require creativity, communication, and teamwork, regardless of the discipline. Within the design roles observed, the most coveted tangible skills include a portfolio, sketching skills, and knowledge of software such as Adobe and Rhino. That said, there is a noticeable difference between the **tangible skills**† sought in general design roles (i.e. industrial, graphics, UX/UI) and engineering-design roles. The latter requires knowledge of math, sciences, kinematics, statistics, and economics. These skills are significant when it comes to defining engineering-design within the context of an undergraduate education since more than half of the general Design aftermarket does not require these analytical skills. Nevertheless, engineering inevitably requires design principles. For example, Nicolai points out that "over 40% of engineers in the aerospace industry are involved, either directly or indirectly, in design related tasks (conceptual design, preliminary design or detail/production design), less than 5% of the design engineers are involved in conceptual design, approximately 20% are involved in preliminary design, and the remainder are doing detail/production design work on projects."

Despite that, almost all of the jobs required data visualization, **CAD**‡, and sketching skills, as well as a portfolio. Neeti Banerji, a RISD '17 alumna, pointed out how her "Portfolio" class at RISD was an essential part of getting a job since it built "a body of work relevant to [her] field of interest" and allowed for her, as well as her peers, to have jobs lined up for after graduation. Alex Lo, a Brown '18 alumnus and engineer at McMaster-Carr§ within the Design and Development department, stated that Brown did give him a huge breadth of skills but ultimately forced him to "look for external opportunities to hone [his] design skills," and that a successful designer should be creative and be able to make decisions on the fly.¶

There are many design roles where design principles are applied and do not require knowledge of technical programs, like a design researcher at IDEO. This position requires "impactful and passionate communication skills" and "experience working in highly collaborative design teams, or other multidisciplinary teams" and places a higher emphasis on having a diverse background.[39] This role, however, has "preferred" requirements that include knowledge of such technical programs, and many roles will still look for these skills. Shuya Gong, a Venture Designer at IDEO, substantiates this with the following overarching themes:

- Most students turn to design firms, consulting firms, or even freelance work post-graduation
- Most design-curious students often attend graduate-level programs at some point in their career
- For applications, almost all require an extensive portfolio and knowledge of design softwares
- Concentrations/majors need to have breadth and depth (T-Shaped)
- Understanding human beings is a key, fundamental area/aspect of this field of study

Regardless of the specialty within design, though, companies look for students who are able to provide solutions to open-ended problems, which is one of the main characteristics of design thinking approaches. Creativity and analytics are two areas that have been commonly stereotyped as classifications of the "right brain" and "left brain," respectively, as Figure 15 points out, though this has been proven to be scientifically inaccurate.[40] Nevertheless, the figure encapsulates a visual interpretation of how creativity and analytics should converge in any design job, regardless of whether it's engineering-specific or not.

Tsai Lu Liu, Assistant Professor within the Department of Industrial Design at Auburn University, provides an

* See Glossary: Intangible Skills
† See Glossary: Tangible Skills
‡ See Glossary: CAD/CAM
§ McMaster-Carr is a private industrial supplier of hardware, tools, and raw materials that maintains products comprised of mechanical, electrical, plumbing, and utility hardware
¶ Lo's full quote on what makes a designer a designer can be found in the Appendix.

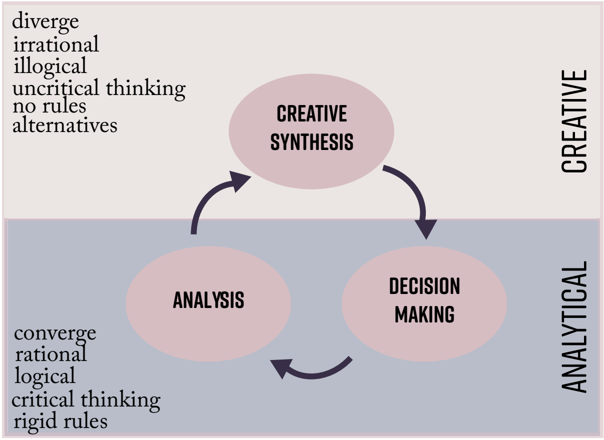


Figure 15: Convergence of analytical and creative aspects of problem-solving approach

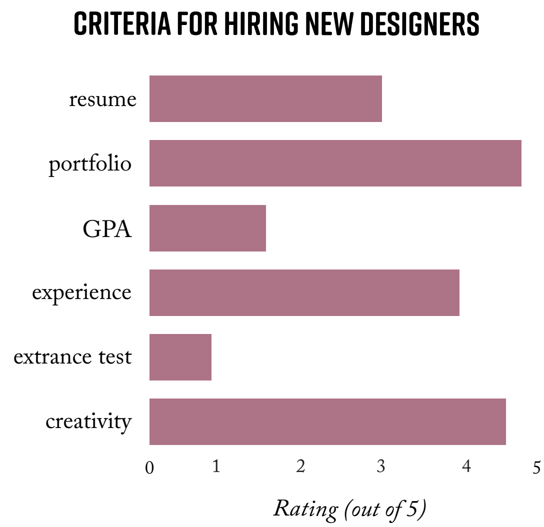


Figure 16: Liu's survey results highlighting criteria for hiring designers

industrial perspective of skills sought in applicants in her study "The Focus of Industrial Design Education: Perspectives from the Industry."[41] She conducted an 18-question survey distributed to 1,343 designers, managers, and executives working for both design consulting firms and manufacturers and reported the following findings:

- 82% of respondents hold bachelor's degrees
- 92% hold degrees specifically in the field of Design
- Respondents ranked most important criteria for hiring new designers, the top being a portfolio, then creativity, then experience. The least important factors included GPA, resumes, and entrance tests
- The most sought-after skills were problem solving, innovation, and sketching. Of secondary importance were teamwork and communication skills, followed by technical engineering, CAD, human factors, and marketing skills

Liu's survey findings stem from an industrial design perspective and are biased as a result; that said, they correlate with the analysis of the job postings. Ultimately, both the research results and the analysis of these postings indicate the importance of having a portfolio alongside the other tangible and intangible skills.

job postings

To further analyze the common requirements of applicants in design roles, the 51 job postings were run through Voyant Tools, which displayed the "count," or the number of times a word or phrase appeared relative to the entire text. The most recurrent words and phrases that came up included "people," "interaction," "creative," "new," and "visual." The frequency at which words were detected in the postings can be seen in Figure 17, where "product" was the third most common word and came up 145 times. These words highlight the earlier definitions of Design as a whole, which is human-centered and innovative but is frequently associated with the creation of a product in engineering-design compared to other design-related disciplines.

The description and responsibilities sections of most of the postings placed great emphasis on intangible skills, highlighting how important it is to develop creativity and critical thinking in a student's design education. Despite the commonalities, most of the postings were vague in their descriptions and responsibilities. Ann Esbeck, Manager of the Innovation Department at Bechtel, explained this observation from the industry's perspective, stating:

> **"We like to keep our job descriptions vague for innovation or design roles because it's hard to describe, and it's difficult to tell applicants what they'll find themselves doing exactly, which is why we look for those soft skills that will make a candidate capable of performing any task and collaborate with different types of people."**

TERM	COUNT
design	470
experience	205
product	145
research	127
user	111
work	111
team	110
visual	64
people	58
interaction	57
new	56
development	50
process	50
data	48
creative	46
strong	45

Figure 17: Frequency at which words appear in all 51 job postings (design & engineering-design)

Her perspective also concerned a new innovation department at Bechtel that requires the candidate to have an engineering, visual arts, industrial design, game theory, or marketing degree, among others. It is clear that, despite the type of design, a student should develop collaboration skills and an ability to deal with the unexpected throughout their education.

Next, we wanted to capture the specific skills that companies looked for in candidates, and because of the overall undefined aspect of the job postings, we analyzed each of their three parts - description, responsibilities, and requirements - separately. The collective job postings can be viewed in the Appendix-3.

descriptions

The descriptions of the postings cover a general narrative of the job itself or how the company functions. As Esbeck indicated, this section is usually kept vague because design itself is difficult to define and a lot of emphasis is placed on those intangible skills. The table below lists the most common phrases that came up and aligns with our earlier observations. While all of the design roles placed an emphasis on creativity and collaboration, a notable phrase that comes up frequently has to do with research skills. In the general design roles, this appears as "**rigorous research**,"* and in the case of engineering-design roles, this comes up as "combining research data insights." This signifies how design and research go hand in hand, and how design principles cannot be excluded from a research institution like Brown. The description also becomes more specific in the engineering-design roles, mentioning technical phrases like "**signal processing**," †which further highlights the analytical skills that separate engineering and some industrial and graphic design roles from the rest.

GENERAL DESIGN	ENGINEERING DESIGN
• tight-knit collaborative group of designers • communications • creative • impact on • rigorous research • user experience	• collaborative group • focus on the user • multi-disciplinary team • signal processing • user experience (UX) • product management • combining research data insights

Table 8: most frequent phrases and words that came up in "description" section

responsibilities

The "responsibilities" section also carries the same ideas mentioned before, but is more specific in terms of the general daily tasks someone would carry out in a design role (Table 9). The majority of them mentioned "design iteration," "proposals and presentations," and "human centered." These are key aspects in design thinking and application and are a part of what we want to encapsulate

* See Glossary: Rigorous Research
† See Glossary: Signal Processing

in our proposed design field of study, which is discussed later on. A key difference between the engineering-design roles and the others is that the former commonly brings up the idea of creating a "product." A lot of these postings, including Product Engineering at Asana and Design Engineer at Swarovski, focus on fabricating a physical creation using tangible skills like knowledge of CAD and geometry. This observation is brought up again later on in our examination of the faculty within Brown's School of Engineering and in deciding how well design would fit within S.O.E. The fact that many of these jobs require design thinking approaches and an understanding of design iteration is important when considering whether a student is able to graduate from Brown with these abilities.

GENERAL DESIGN	ENGINEERING DESIGN
• participate in design critique • design and execute rigorous research • encourage design iteration • design and usability testing • proposals and presentations • qualitative and quantitative • 3D modeling • human-centered • collaborate with engineers	• build and ship • thinking in terms of design systems • execute rigorous research • next generation • collaborate with product • design and marketing • design solutions to mockups and prototypes • scientists and researchers • design rationale • effectively communicate

Table 9: most frequent phrases and words that came up in "responsibilities" section

requirements

The last, and most important, section of the postings focuses on the "requirements." In almost all of the 51 postings, the most common requirements include experience with one of the scripting languages like HTML, CSS, and JavaScript (JS), and one digital softwares like Adobe Illustrator or Photoshop (Table 10). Most have a preference for someone with a degree in design, while the engineering-design roles require an engineering degree. The table below displays the other common phrases that come up in this section. Notable requirements that frequently come up are "knowledge of methods for gathering research data," "problem solving skills," "hands on experience," and "design-related projects." These are all aspects that can easily be incorporated into classes and would give a student the necessary skill set needed for these design roles. Because a majority of them only require experience with one scripting language or one digital software, it is also feasible to incorporate these into class projects.

GENERAL DESIGN	ENGINEERING DESIGN
• portfolio of work • degree in design • design related projects • HTML, CSS, JS • Adobe InDesign, Adobe Photoshop, Adobe CC, Adobe Illustrator, After Effects • programming scripting experience a self starter who collaborates • problem solving skills • brainstorming sessions • UX skills • knowledge of UX research • product development	• relevant design experience • degree in engineering • communication skills • collaboration skills • Adobe Creative Suite • hands on experience • HTML, CSS, JS • Adobe CC • qualitative and quantitative • design methodology • hardware platforms • portfolio • scripting languages • product development

Table 11: most frequent phrases and words that came up in "requirements" section

The main difference between the general design roles and engineering-specific roles comes down to the latter requiring math and science abilities. For the most part, they all require an ability to switch between quantitative and qualitative human-centered thinking, design iteration, collaboration, as well as having a portfolio, knowledge of design softwares, and basic coding skills. Despite the differences between the many design disciplines, employers within the broad design industry seek similar requirements, therefore it is critical to incorporate these aspects into the undergraduate education of a student. The most coveted skills from the industry were found to be collaborative skills and creativity, as well as a portfolio. The next sections illustrate whether Brown successfully meets these standards, which skills it fails to incorporate into its curriculums, and how that can be remedied.

SUMMARY OF FINDINGS

BROWN UNIVERSITY

In the prior sections, we have defined design practice as creation with intention and explained how the focus on process and social impact in Design are aligned with Brown's institutional mission and distinguish Design at Brown from Design at other institutions. The growing interest in design practice in other institutions, in industry, and from Brown students and faculty, compounded by the lack of formal Design education at Brown warrant an increase in curricula offered by the University.

SCHOOL OF ENGINEERING

We believe that Design at Brown should be housed in the School of Engineering. Almost fifty percent of students surveyed indicated that a greater emphasis on design would have encouraged them to stay in Engineering. We recognize that the SOE faculty surveyed have different views on the value and purpose of Design within Engineering; however, more than half of the engineering faculty believe that a Design degree has a place in the Engineering department.

Integrating design practice into the Engineering department is critical for applying theory. A study produced by the Carnegie Foundation for the Advancement of Teaching argues, "In the engineering science and technology courses, the tradition of putting theory before practice and the effort to cover technical knowledge comprehensively allow little opportunity for students to have the kind of deep learning experiences that mirror professional practice and problem-solving."[42] Our survey results demonstrate that Brown Engineering students agree with this sentiment. The authors of the Carnegie Foundation paper also claim that Design and emphasis on practice "would give coherence and efficacy to the primary task facing schools of engineering: enabling students to move from being passive viewers of engineering action to taking their place as active participants or creators within the field of engineering".[43] If Engineering students are to intervene in the wicked problems facing the world today and in the future, they must have experience with the process of applying the theory they learn in the classroom. The practicing of design enables Engineering students to learn collaboration, informed questioning of current practices and systems, as well as iterative problem-solving.

Thus, we believe Design is critical to the study of Engineering, and we urge the SOE to capitalize on these intersections and student interest to further its success as a premier Engineering school and to help cultivate empathetic, creative, and thoughtful Engineers, who are well versed in theory and practice, and can succeed in their Engineering field of choice.

RECOMMENDATIONS & FUTURE DIRECTIONS

DESIGN AT BROWN GOALS

Short Term (<1 year)	*Intermediate (1-3 years)*	*Long Term (3< years)*
- Defining Design for Brown - Guide to Design ICs - Connecting current faculty - Intro to Design course	- Hiring of additional adjuncts - Design advising resources	- Creation of a Design concentration - Creation of a Design department
- Improvements to the BDW - Evaluate the meaning of an Engineering BA	- Further implementation of ENGN GISP recommmendations	

DEFINING DESIGN FOR BROWN

After examining the data and in consideration of the information we have gathered, we believe the first step towards the inclusion of design is to define it within the context of Brown University. Like any other concentration, it is key to define the goals and mission. As such, we propose this working definition of design.

The objective of a design education is to:

- To create with intention with a foundation of research and analysis
- To inspire change with considerations of interacting systems, responsibility, and social impact
- To work collaboratively and engage with the communities and groups which design serves
- To comfortably work across and within various media

Moving forward with that definition, we would like to extend the definition to independent concentrations. By creating a unified definition of design, we hope to create a model for design independent concentrations that will focus students' effort on viewing design through their desired means (biomimicry design, product design, etc), instead of reinventing Brown's definition of design. Below, we analyze the fundamental aspects of creating a design Independent Concentration pathway.

GUIDE TO DESIGN IC

DESIGN IC TRACK

Strengths	*Weaknesses*
Creates a path through the CRC for designers	Doesn't add to the current curriculum, advising or resources
Helps establish a definition of design and start to tie together some resources	Doesn't help students define design + navigate through all the administrative hurdles
May attract some advising	Students are still restricted by class availability
Relieves some of the issue with the lack of a design degree	Will not be adequately advertised to prospies or new students

Currently, Independent Concentrations (IC) are designers' main method of achieving the degree they desire. These degrees are usually about 16 credits long and amount to a BA in a personalized track of study. The proposed design IC track would have five outlined areas of study that a student must learn to fulfill Brown's definition of design. These five skills would be broad categories, namely: 1) An Understanding of Human Behavior, 2) World Context, 3) Analysis and Research

Methods, 4) Visual Thinking and Communication, and 5) Execution of the Design Process. This track would have a CRC-approved definition of design at Brown and a list of classes that fall under these categories. By imposing this set structure upon the IC process, it would help designers work within a structure to define their own education. Furthermore, they would have the freedom to suggest further classes that fall under these skills.

One of the strengths of this approach is that it streamlines the IC process, which normally takes up to a year to complete, takes dozens of hours of work, and causes significant stress. This process is rigorous in a way that takes over much of a student's free time, preventing them from participating in many extracurriculars. Furthermore, streamlining the IC process would alleviate the CRC as they have evaluated over 18 different design ICs since 2002.[44]

Despite the many positive aspects of this degree, there are some significant drawbacks to establishing it permanently within the CRC. First, it does not guarantee the expansion of the current curriculum, advising or resources for designers. This means that designers have to draw their classes from the fluctuating pool of poorly tailored classes. Furthermore, it does not promise students spots in highly desirable classes, meaning that they may face significant hurdles in completing their IC.

Finally, since this degree is unofficial in the eyes of the University, it will lack outward facing visibility to prospective students and first years. This ultimately hinders the growth and visibility of the design community.

ADJUNCTS

Brown has several faculty members who are interested in and employ design processes in their teaching and research. However, after talking with several designers, most notably those from design consultancy firms such as IDEO and Ideas42, we recognize how design in the classroom and in theory can differ from design in practice. Most professors tend to focus on theory, but design is much more application based and needs instructors who have experience applying it on many levels (systems, graphic, product design, etc). Thus, Brown's design program must incorporate professors who serve as adjuncts. We have considered the qualities ideal for such a position, especially an individual who practices design as their primary role in their professional career, more than six to eight years of professional Design experience, and is passionate about their field and teaching others. Below, we review three individuals whom we believe exemplify qualities critical for adjunct professors in Design.

Jessica Mason is a Brown alumnus who founded and serves as the Chief Executive Officer for the Social Impact Studio, a design studio based in Boston that works with nonprofits. Prior to her work at the Social Impact Studio, Mason has experience in the social innovation space on six continents and thus has seen how design works in an international context.[45] Mason is passionate about supporting the Brown community and is open to teaching a course on design for social impact, a course which we believe serves our overarching goals for design to be an interdisciplinary, critical and socially conscious practice.

Elizabeth Hermann is a Professor of Landscape Architecture at RISD where her courses focus on transdisciplinary design in development, sustainability, place, and identity, among other topics. Hermann also founded and serves as the Co-Director of DESINE Lab, described in her online biography as:

> **an applied research lab where faculty, students and alumni from RISD, together with students from Brown, work with partners in South Asia, Africa, Latin America and the US to develop and implement design-based integrated multi-scalar social and economic strategies for under-resourced, post-conflict, and post-disaster societies. The work covers the arenas of human capacity building, livelihood development, women's empowerment, entrepreneurship, education and institution building, and the built environment and sustainable practices.**[46]

Hermann's socially conscious courses at RISD and work with the DESINE Lab will interest many of the students interested in socially and environmentally **sustainable design*** practices. She can also help students explore the ethics and power dynamics involved in creating with a community and contextualizing design in historical and geographical contexts.

Mickey Ackerman is a current full-time faculty member at RISD and the Chief Design Strategist at the Business Innovation Factory (BIF) in Providence.[47] Ackerman is currently teaching foundational courses in Spatial Dynamics at RISD and was formerly a head of RISD's Industrial Design department for 15 years.[48] In his classes, Ackerman emphasizes "multidisciplinary teamwork,"[49] which is a critical tenet of our proposed program. Ackerman's extensive experience in Industrial Design and relationships with academic institutions, including RISD, Massachusetts Institute of Technology, and Harvard University, and with professional institutions that focus on social impact design, such as BIF, can expose students to various academic and professional pursuits of design within and beyond the classroom.

We understand that there are budgetary limitations and hope that there is a possibility of an adjunct position materializing in conjunction with the RISD-Brown Graduate program. Regardless of how we approach this task, onboarding more industry-based faculty is essential to a successful design curriculum. Therefore, if Brown is dedicated to incorporating more design into the Engineering department and the University, the first step will be hiring experienced design adjuncts.

CONNECTING CURRENT FACULTY

Over the course of the semester, students met with the following 18 faculty members (Table 15). Since design is an interdisciplinary field, students and faculty members alike are scattered across different academic departments (ENGN, CS, VISA, ENVS, HIAA, CLPS). Faculty members are up-to-date about classes and research pertaining to design within their department. However, outside of their departments, faculty members generally felt uninformed.

LIST OF FACULTY

Dean Beresford	William Heindel	Dietrich Neumann
Dean Rodriguez	Chris Bull	Paul Myoda
Celinda Kofron	Kurt Teichert	Jeff Huang
Ruth Bahar	Joachim de la Cruz Krueger	Ian Gonsher
Jason Harry	Daniel Stupar	Stephen Lubar
Kenny Breuer	Steven Sloman	

Table 15: Table containing all the Brown University faculty with which we have met.

There are a number of simple ways to create a more central dialogue, including:

Design Open House – An event at the beginning of the year where students and professors share their design-related research and projects. An open house is a simple way to make the study of design more visible and accessible to students at Brown. This event could be held in the Engineering Research Center (ERC) Lobby.

Lunch and Learn – A monthly lunch for "faculty champions" to learn about progress in implementing this proposal, what Design@Brown, the student group behind this proposal, is working on, and upcoming design events on campus. These lunches are a regular, informal way of keeping faculty supporters involved and informed.

Retreat – Similar to the School of Engineering retreat, a design retreat would provide a full afternoon to discuss the future of Design at Brown. A retreat would be most impactful after a more formal community surrounding design has been established.

The faculty members students with whom we met are uniformly interested in supporting design. However, they are not sure what they can do to help. An outside party, such as Design@Brown, must provide opportunities for existing faculty to support design initiatives.

* See Glossary: Sustainable Design

CLASSES

A key part of developing any sort of design concentration is the development of its foundational entry-level courses. We recommend the creation of three courses: Design Theory, 2D Tools, and 3D Tools. We have developed an outline of the primary Design Theory course based on our research and personal experience with design and curriculum development.

design theory course suggestion

In building this design course, we began with the learning objectives, dividing them into three categories: Content and Knowledge, Skills and Practices, and Habits of Mind. In the Content and Knowledge section, we included very concrete pieces of information in which we want students to become fluent. Thus, this category includes understanding the history and evolution of Design and design practices and the ability of our students to make connections across time. They also need to be able to understand the dynamic parts of the design process (Discovery, Interpretation, Ideation, Experimentation, and Evolution) and why each is important as well as understand the elements and principles of bottom-up research and design thinking. Students also must be able to understand applications of design thinking and practice. Finally, a primary learning objective of this course is for students to understand the ethics of design process and context in which they are designing.

The Skills and Practices learning objectives are less concrete but more about the practical techniques that students will take away from the course. Broadly, this means that students will be able to apply design thinking to at least one project throughout the course of the class and after completing the course will comfortably take risks and experiments in their time at Brown and beyond. More specifically, these learning objectives include skills like visual thinking, effective interviewing, persona development (including empathy maps and user journeys), need statements and "How Might We…?" development, brainstorming (both in a group and individually), techniques to choose an idea, and prototyping (to test assumptions) to create successful projects.

LEARNING OBJECTIVES

CONTENT & KNOWLEDGE

history and evolution of design and design practices and the ability to make connections across time

dynamic parts of the design process and why each is important

elements and principles of bottom-up research and design thinking (as outlined by IDEO)

applications of design thinking

ethics of design process and context in which we are designing

SKILLS & PRACTICES

apply design thinking to at least one project throughout the class

comfortably take risks and experiment in their time at Brown and beyond

comfortably applies visual thinking, effective interviewing, persona development (empathy maps/user journeys), need statements/HMW, brainstorming (group and individual), techniques to choose an idea, and prototyping (to test assumptions) in their projects

HABITS OF MIND

productive and supportive collaboration with others

apply inquiry-based and empathic approach of design thinking into their everyday lives

understand social responsibility of themselves as a designer

Figure 19: Outline of course learning objectives.

The Habits of Mind is less concrete than the other learning objective categories but still incredibly important and includes the mindset shift of students in this course and their global perspective on design and their role in it. Directly, these learning objectives include collaborating productively and supportively with other members of the Brown community, applying the inquiry-based and empathic approach of design thinking into their everyday lives as a Brown student both on and off campus, and students will understand the social responsibility of themselves as a designer.

After defining these learning objectives, we considered different methods to be used in the classroom for students to actually learn this material. While an introductory class, we sought to create a course that was engaging and project-based, with only a few lectures. Altogether, the course will be split into the following categories:

- lectures
- group discussion
- guest lectures and Q&A
- presentations
- project work time
- field trips

Lectures will be primarily front-loaded to the beginning of the course, focusing on the history of design and then intermittent and short lectures will be used to explain different technical skills and applications. A large portion of class time will be used for discussion, using class time to discuss assigned readings, projects, and case studies. We also included time for guest lectures, hoping to bring around four outside designers to speak on their work or run workshops throughout the course of the semester. All of these guest lectures or workshops will include time for students to engage in discussion with the guest.

COURSE ASSESSMENT

REFLECTION

self-evaluation
group evaluation

COMMUNICATION

presentations
project write-ups

Figure 20: Division of course assessment.

Another key skill we want our students to develop is effectively communicating both their solutions and process through presentations and public speaking. A portion of class time will be dedicated to these presentations as well as the sharing of feedback between different students. Smaller portions of class time will be dedicated to project work time and field trips. Project work will primarily be completed outside of class time, but on a couple of occasions, there will dedicated time to work on them in class where groups are either directly working on aspects of the project, or using time to check in with the professor to get feedback or work through a problem. Field trips will also occur to provide a real-world perspective on the design process outside of Brown.

We have developed preliminary guidelines for assessing whether students have learned the objectives of this course. This course would be mandatory Satisfactory/No Credit (S/NC). Many writing-based undergraduate courses at the University already have this same designation as an appropriate measure for assessing performance on course objectives that cannot be captured by letter grades. We believe that mandatory S/NC is critical to the success of this course: though the core of design theory and practice is considering possibilities within and beyond conventionally held norms, student anxieties about grades may hinder the creative process since students may conform to the professor's personal design practices to attain a desired grade, rather than experiment and practice the design process. Mandatory S/NC would alleviate these anxieties and allow greater creativity. Student progress would be assessed by group evaluations completed by group members and self-evaluations completed by each student after each project. Professors and peers would also evaluate students' presentations and "write-ups" of their projects for their application of design processes and effective communication of their ideas. Each week, students would produce a weekly reflection to readings and course material. In discussing this course assessment, it is important that the assessment not be viewed as "too easy" to warrant a "free rider" problem such that students do not participate fully in the course. Eugene Korsunskiy, Dartmouth "Design Thinking" and "Senior Design Challenge" professor, provided positive feedback on this course proposal.

CONCENTRATION CREATION

Beyond new courses, we would like to propose the creation of a degree path. Below we suggest two methods to bring about design as a part of Brown's curriculum: a design certificate or a Design+ BA. Of these two, we believe that the Design+ BA offers the most rigorous solution to the problems presented above.

design certificate

DESIGN CERTIFICATE

Strengths	*Weaknesses*
4-6 class structure that marks a 'proficiency' in a particular study	Easy to attain, waters down the theoretical value of the 'certificate' and of Design
Useful to focus studies and expose students who wouldn't traditionally pursue this venue of study	Vague understanding outside of Brown of what a 'certificate' entails
Motivation for students to study design and gain an understanding for the practice	Design classes will be diluted by less passionate students and may be more difficult to take part in

Table 16: This table compares the strengths and weaknesses of implementing a design certificate at Brown.

From conversations with President Christina Paxson and Peggy Chang of the CRC, it appears that Brown University is investigating the possibility of a path for minors known as 'certificates'. While the details of these degrees have not been fully established, we will define a 'certificate' for the scope of this paper. A certificate is awarded to students who have fulfilled a 4-6 class requirement designed to give them a 'proficiency' in a particular skill set. Examples of a skill set include entrepreneurship, language or teaching skills and more.

Certificates are an interesting proposition by the University and could be an advantageous tool for designers. They offer a reward for taking classes that would be fundamental to a full design degree or education. Additionally, the minimal amount of classes required to complete a certificate allows a wide variety of students to acquire this skill set. This exposes a large group of the student body to a new way of thinking and allows them to gain an understanding of the value of designers. These are inherent advantages in creating a design certificate, as it attracts a large following to a form of education that is underrepresented at Brown.

Conversely, there are significant weaknesses to this form of award. First, the depth that can be attained by 4-6 classes is minimal. This means that a design certificate can only start a conversation about design at Brown and leaves a group of students assuming they are experts in a field of which they have only scratched the surface. We believe that many students might seek out this option as an addition to their resume, especially since minors do not currently exist at Brown. This popularity as a simple 'addition' to your primary field of study diminishes the value of a design education. Similarly, the potential popularity of certificates lends itself to the dilution of passion within the design community and a degradation of the quality of design education. Furthermore, an influx of students into design classes may make these classes impossible to enter for designers as they will quickly fill-up each semester.

Additionally, the creation of a certificate does not facilitate the increase of resources or advising within the design community. Combined with an influx of potential designers, this may stretch our already thin design resources even further. Finally, in terms of aftermarket, the value of a certificate is likely to be minimal. Companies outside of Brown's sphere of interest are likely to be unsure of the value of a design certificate and write it off as an easy track or a simple achievement. This hurts the viability for design internships and jobs in the years in and around a student's time at Brown.

design+

A second proposition is a design, dual-concentration program. This program would have to be applied to directly by students and would have limited acceptance. It would consist of a BA in Design and a second BA in an area of the students' choosing. This degree currently has the loosest definition as it will be subject to change as suggestions arise from the administration and faculty that aid in passing it.

DESIGN+ BA

Strengths	*Weaknesses*
Adds to the current curriculum, advising or resources	Difficult to obtain
Difficult to obtain	Requires hiring of design professors and investment into design spaces
Draws alumni donations to expand current design resources	May face strong opposition
This structure allows **additive knowledge*** (ie. professors can build knowledge from one class to the next as there will be an expected prior knowledge established by prerequisites)	
Enables depth of study	

Table 16: This table compares the strengths and weaknesses of implementing a design certificate at Brown.

Generally, this degree seeks to address concerns of the depth of education and a lack of curriculum, advising and resources. By forming a concentration, there would be a fundamental need to hire faculty skilled in teaching design, such that a design core could be established. These faculty, in turn, would be able to serve as advisors to designers and facilitate further extracurricular design. This concentration would give a designer both a fundamental understanding of design as a school of thought and an understanding of a secondary field to which design principles could be applied.

Another strength of this concentration is it caters to a unique and untapped group of prospective students, offering Brown a chance to add more diversity of thought to its current population. These students after graduation offer an opportunity to tap alumni for donations to expand current design resources, building upon the potential for a strong design degree.

With these advantages in mind, there are clear drawbacks to this degree. Passing a design concentration, hiring faculty and establishing resources are all enormous propositions and will likely face oppositions at all levels. As such, much overhead work will have to be done to mitigate these concerns and pass a degree that's amenable to faculty, students, and administration. An example 4 year course plan for the Design+ degree can be found in Appendix-8.

ADVISING

goal

We need to find an advising structure which can help students understand if design is a good fit, plan courses, and navigate the aftermarket. This is a challenge because we need to identify faculty advisors who are knowledgeable about the practice of design in a number of different fields.

research

BEO and Behavioral Decision Sciences are concentrations that draw almost exclusively on other departments for courses (see Appendix-4 for research). Similarly, Design+ would pool its required classes and advisors from Engineering and other departments. Therefore, we looked at the BEO and Behavioral Decision Sciences departments' advising as a model. We also met with Professor Sloman, the sole Behavioral Decision Sciences Concentration Advisor.

There about 18 students concentrating in BDS, far fewer than the ~190 in BEO.[50] To determine how many advisors Design+ will need, we spoke to Professor Sloman about his advising load. Professor Sloman advises all 18 students in their course planning. He said that this is not burdensome and that if the concentration doubles in popularity, he would still have the bandwidth to be the sole concentration advisor.

The advising burden comes with advising capstone projects. Professor Sloman said that advising more than 5 capstone projects is time-consuming and would

* See Glossary: Additive Knowledge

start to detract from the amount of time he could spend with each student. It is important for a student to have a capstone advisor with a relevant area of expertise. This is where Behavioral Decision Sciences uses Area Specialists, faculty members whose research intersects with the topic of Behavioral Decision Sciences. Although the Professor Sloman says the Area Specialists have been underutilized, they exist to serve as capstone advisors. If BDS balloons in popularity they may also begin to serve as concentration advisors.

advising for design+

An advising structure similar to that of Behavioral Decision Sciences (BDS) would best suit the needs of Design+. Because Design+ will initially be a small concentration, BDS's advising structure better matches the needs of Design+ than BEO's advising structure. There must be a faculty member to champion the concentration and be knowledgeable about its requirements. This faculty member would serve as the sole Concentration Advisor, just as Professor Sloman does for BDS. As BDS has demonstrated, a single concentration advisor has enough bandwidth to advise the students in a small, new department.

Additionally, Design+ has a need for Area Specialists. Both BEO and Behavioral Decision Sciences have "track advisors" or "area specialists" to accommodate the wide range of interests that concentrators will have. This parallels the study of design, a topic which can be applied to a variety of fields.

Faculty members who could serve as Area Specialists are grouped by affiliated department in the following table (Table 18).

An advisor should support their Design+ student with:

- Academic planning and course selection
- Exploring design through a breadth of academic disciplines and extracurriculars
- Navigating career choices and the aftermarket

The Concentration Advisor will be equipped to help students with academic planning and course selection. They can also point students to extracurriculars, such as STEAM and Better World by Design. However, advisors may be unable to offer significant help with navigating the aftermarket. There are few professors of practice at Brown, potentially hindering their ability to provide aftermarket guidance. Aftermarket guidance is an important yet untraditional responsibility for an advisor. However, we believe it is important for students to have this guidance. In our survey of current undergraduate students, nearly two-thirds of respondents indicated that they would like more aftermarket advising in design.
The Concentration Advisor will not be expected to offer this guidance. Rather, the Concentration Advisor can rely on a Department Undergraduate Group (DUG) and a network of alumni to which they can refer students. There are a number of students who have done Design independent concentrations and

Table 18: List of potential area specialists who could help with Design+ advising. Bolded names represent parties who have agreed to be part of our advising structure.

AREA SPECIALIST

ENGN	*VISA*	*HIAA*	*CLPS*	*OTHER*
Chris Bull	**Paul Myoda**	**Dietrich Neumann**	**Bill Heindel**	Jeff Huang (CSCI)
Ian Gonsher	Daniel Stupar	Steven Lubar	Kathryn Spoehr	Alan Harlam (PLCY)
Fran Slutsky				**Kurt Teichert (ENVS)**
Celinda Kofron				

graduated. These young alumni may be interested in serving as an unofficial resource for navigating the aftermarket.

Academic departments, including BEO and Behavioral Decision Sciences, lean on DUGs (Department Undergraduate Groups) to plan programs and foster community. There already exists a community of students at Brown who could fill this role. Design@Brown is a group of passionate Brown students dedicated to improving and expanding the role of and resources for designers at Brown. This year, D@B has:

- Hosted workshops on essential design skills, such as a "How to Portfolio" workshop.
- Held office hours for students interested in learning about what an IC in design means and entails.
- Collaborated with other clubs and programs on campus, such as Innovation Dojo, to demonstrate what design means in their context.
- Created a website (designatbrown.com) with design resources, including how to enroll in RISD classes, makerspaces on campus, and recommended clubs and courses.

D@B could transition into the role of a DUG, fulfilling the critical role of helping students navigate extracurriculars and portfolio-building.

Taken together, the Concentration Advisor, Area Specialists, and DUG create a strong support system for Design+ students. This support is a large improvement from the advising available to students who conduct an Independent Concentration. Rather than have a sole advisor after completing an IC, students would have access to a network of support. Access to specialized advising is a major motivation for creating the Design+ concentration. Having a visible concentration allows for a rich support system and therefore a better academic experience for students. Furthermore, a structured alumni network will help students be introduced to the industry. This is crucial in allowing students to understand if design is right for them, and if so make the transition to post-graduation easier for students.

PROPOSALS FOR DESIGN IN ENGINEERING

CLASSES

As has been shown in the results of the Engineering Student Survey and was looked at in the 2016 Undergraduate Engineering Experience GISP, there is an interest and a need for more application based learning within the SOE. The SOE has successfully accomplished the incorporation of the design process into the very beginning and the end of their undergraduate education. Students are first exposed to the design process in ENGN 0030 (Introduction to Engineering) and ENGN 0040 (Dynamics and Vibrations). They then have the option to take capstone-style classes such as ENGN 1000/1001 (Projects in Engineering Design), ENGN 1740 (Computer-Aided Visualization and Design), and ENGN 1930M (Industrial Design.) But the focus on design and application are still missing from most classes taken in an engineer's sophomore and junior year.

The previous Undergraduate Engineering Experience GISP group's recommendations vastly improved the open curriculum within the School of Engineering, adding greater flexibility to the Sc.B. However, the School of Engineering is still thoroughly underserving its Design-interested students. We want to reiterate that the implementation of the recommendations [51]made in this GISP would give engineering students more opportunities to explore Engineering Design.

BDW MAKERSPACE

The Brown Design Workshop is a makerspace that can be utilized more by courses both within the School of Engineering and the rest of Brown and can be used in parallel with Design courses to fortify both the tangible and intangible skills of a student. As such, we believe that the increased funding and support of the Brown Design Workshop would help to augment design across disciplines. Specifically, after interviewing monitors and managers, we have identified the need for:

1. **Improved hardware support for design software.**
   Currently within the Brown Design Workshop, the computers that support the design portion of the space are often forgotten about. The budget required to update computers and the support in updating software is often nonexistent. As such, computers in the space can not efficiently run design software required to use many of the tools.

2. **Increased Accessibility**
   Despite the Brown Design Workshop being an open makerspace, it is often overlooked and underutilized by students outside of engineering, VISA, architecture and RISD. As such we ask that sign space be allocated on the outside of Barus and Holley to advertise the location and existence of the Brown Design Workshop as an open makerspace. Additionally, we have identified courses (see Appendix-5) that have the potential to make use of the Brown Design Workshop. This is not an extensive list, but starts the conversation of how design might be integrated in non-traditional courses.

3. **Increase Usage Within Engineering Curriculum**
   The Brown Design Workshop is the ideal opportunity to allow for the intersection of theory and application. Encouraging the use of the Brown Design Workshop in open-ended design projects offers students the opportunity to creatively display a variety of skills to solve a set of problems. As such, we believe current engineering courses should be encouraged to incorporate this space into their design projects.

EVALUATE MEANING OF BA IN ENGINEERING

In addition to supporting in the expansion and role of the BDW in the Brown design space and adjusting current engineering courses to reflect a greater commitment to the teaching of the design process and application of engineering theory, we believe it would be advantageous for the School of Engineering to turn its attention to their offering of a Bachelor of Arts (BA) in Engineering and think critically about the meaning of this degree.

The BA in Engineering is a degree that is often utilized by students who feel an affinity for the theory of creation and problem-solving knowledge affiliated with engineering but are disappointed in the lack of application and emphasis on the implications of that creation. The smaller number of credits that the BA requires allows them to explore subjects that give them the knowledge and opportunities they find the BS requirements lack.

Currently, the BA is extremely flexible, almost to a fault, and does not have a clear objective for students or the school to understand the knowledge that is contained within this degree. In the next section, we propose that perhaps these two problems could be each other's solutions.

What does it currently mean to get a Bachelor of Arts in Engineering at Brown University and what should it mean? The current definition of the BA in Engineering is as follows:

> **Engineers make decisions, by collecting and analyzing data; using scientific principles to formulate analytical models of a process; and predicting the outcome of candidate solutions to a problem. They use their creativity to identify innovative solutions to challenging problems. These skills are valuable not only in technical careers, but also in fields such as public service, environmental policy, architecture, teaching, technology management, finance; entrepreneurship, or patent law. A foundation in engineering will help prepare you for the future, no matter what your aspirations may be.**
>
> **The Engineering A.B. degree is offered by the School of Engineering to enable students to combine a rigorous and interdisciplinary foundation in engineering with the diverse opportunities offered by Brown's liberal arts curriculum. With only ten required courses, it has the greatest flexibility of all the School's degree programs.[52]**

In this definition, the main goal of an Engineering AB seems to be "general problem solving" that can be applied to any field. However, these problems still fall under the category of **defined**[*] (i.e. they are well articulated and often have defined processes needed to solve them) and do not recognize the importance of problem-solving when dealing with ill-defined problems.

Additionally, there is no recognition in how classes are taken in a non-engineering "liberal arts curriculum" can influence what you learn in engineering -- discussion is only on how engineering can apply to the other elements of your education. This is where we believe the new definition for Engineering should be reconsidered. Instead of the BA only being a degree that gives you knowledge in engineering theory and skills in solving defined problems, the BA should be an opportunity for students to engage in engineering material and non-engineering material that influence each other and in turn, allow greater insight into both.

Putting an emphasis on design education is the bridge that will connect engineering to non-engineering subjects. Taking psychology classes can influence the way an engineer thinks about their users needs and in turn an engineering degree can influence how a solution to a user's problems might be created. Taking a history class can influence an engineer by giving context of the problem they are solving and in turn engineering can

* See Glossary: Defined Problems

influence the complex analysis of historical systems. Taking economics classes can influence the way an engineer understands the economic boundaries of the products they create and in turn engineering can influence the financial constraints that define **product development**.* By creating a bridge for engineering to inform a liberal arts education and liberal arts education to inform engineering, design and the BA in Engineering can becoming a more meaningful part of a students education.

If the Engineering Department would like to examine this idea more thoroughly, we recommend reading the NASEM Critique on Integrating Higher Education in the Arts, Humanities, Sciences, Engineering and Medicine and the NSF Liberal Studies in Engineering Feasibility Study.[53,54]

* See Glossary: Product Development

CALL TO ACTION

In this process we have examined design and design in education from different perspectives: as analytical researchers, passionate students, future engineers, and as members of the Brown community. We found that for many students, Brown's education is incomplete without an education in design. We have proposed a multitude of reasons why this is and ways it can be accomplished, most notably the Design+ program. The School of Engineering is in the unique position of being able to implement these suggestions and serve as the home for design at Brown and as a model for other schools. Ultimately, it comes down to this: for Brown to educate and release true changemakers into the world, our students, whether in engineering or not, need to be able to understand and apply effective problem-solving, empathic creation, and engagement in the interdisciplinary study of design.

APPENDIX

1. EXISTING DESIGN-ORIENTED CLASSES AT BROWN

While not comprehensive, this list provides examples of existing courses at Brown that involve design and can be connected by students completing a Design+ program or pursuing design in some other way.

Archaeology
ARCH 1881 - An Introduction to GIS and Spatial Analysis for Anthropologists and Archaeologists
ARCH 1882 - Introduction to Geographic Information Systems for Environmental Applications

Biology
BIOL 0400 - Biological Design: Structural Architecture of Organisms
BIOL 1140 - Tissue Engineering
BIOL 1150 - Stem Cell Engineering
BIOL 2010 - Computational Approaches to Biology

Biomedical Engineering
ENGN 1230 - Instrumentation Design
ENGN 01930L - Biomedical Engineering Design and Innovation
ENGN 01931L - Biomedical Engineering Design and Innovation II*
ENGN/BIOL 1970 - Undergraduate research and design project

Cognitive, Linguistic, and Psychological Science
CLPS 1250 - Human Factors
CLPS 1520 Computational Vision or CLPS 1590 Visualizing Vision
CLPS 1900 - Research Methods and Design

Computer Science
CSCI 1951C - Designing Humanity Centered Robots
CSCI 1300 - User Interfaces and User Experience
CSCI 1730 - Design and Implementation of Programming Languages

Economics
ECON 2150 - Market Design
ECON 1490 - Designing Internet Marketplaces
ECON 1465 - Market Design: Theory and Applications

Engineering
ENGN 1000 - Projects in Engineering Design
ENGN 1010 - The Entrepreneurial Process
ENGN 1930M - Industrial Design
ENGN 0930C - Design Studio

Environmental Studies
ENVS 1400 - Sustainable Design in the Built Environment

History of Art and Architecture
HIAA 0100 - Intro Design Studio

Modern Culture and Media
MCM 0750C - Subtle Machines: Designing for Engagement and Response-ability

Public Health
PHP 2355 - Designing and Evaluating Public Health Interventions
PHP 1820 - Designing Education for Better Prisoner and Community Health
PHP 2355 - Designing and Evaluating Public Health Interventions

Sociology
SOC 1118 - Context Research for Innovation

Theatre Arts and Performance Studies
TAPS 1280F - Introduction to Set Design
TAPS 1300 - Advanced Set Design
TAPS 1281A - Director/Designer Collaborative Studio
TAPS 1290 - Advanced Costume Design
TAPS 1315 - Digital Design for the Theatre

Urban Studies

URBN 0210 - The City: An Intro to Urban America
URBN 1870C - The Environment Built: Urban Environmental History and Urban Environmentalism for the 21st Century

Visual Arts

VISA1800V - Creative Mind Studio (Fishman/Gonsher)
VISA1210K - Pixel/Paint/Print (Tarentino)
VISA 1720 - Physical Computing
VISA 0120 - Foundation Media: Sound and Image
VISA 0130 - 3-D Foundation

2. STANFORD PRODUCT DESIGN CLASSES

ME102/ME103 product realization[55]

This two trimester class is a great example of a class that teaches skills essential to the education of a product designer. It is an intensive manufacturing class in which students learn the techniques and tools in both 2D and 3D to realize design concepts. The tools learned include CAD software (Solidworks), hot and cold metal working, and woodworking. Tools are introduced formally and honed by projects that require the use of the tools. The first project was to design and build a personal logo (using tools such as a 3D printer, a laser cutter, or power tools and wood). The second project emphasized both aesthetics and functionality and was building a scale. The third and final project is building a basic hand operated machine which must be "museum level" quality. The last project that consists of a whole semester and is a full trimester project in which students are asked to take what they learned from last semester and create a client-ready prototype of an idea that they come up with.

ME115A introduction to human values in design[56]

This single trimester class is teaches students the principles and methodology central to the design process. It is focused on enabling students to understand how to tell stories, build rapid prototypes, build empathy, find and address user needs, conduct interviews, and create business models. To cement this knowledge, students have two group design projects where they design a product based on research with a specific group in the real world. This class also exposes students to designers in industry with panels every few weeks that help students understand the value and application of the material that they are learning.

Stanford is one of the only institutions that has a very strong program in design engineering; as such, they are a strong example to look to inspire a deeper design curriculum at Brown. The P.D. program does an especially good job of allowing students the opportunity to explore engineering and its context within design. This integration of traditional engineering theory combined with human centered design principles and process create students that have a strong background in not only what a successful product is for consumers, but how to create it.

3. JOB POSTINGS

This section of the appendix describes the job postings used for aftermarket and industry research.

sensata technologies: product design engineer[57]

Description

At this moment, it is likely that you own twenty or more Sensata products. Our devices are hard at work helping to keep your home and vehicle safe, energy efficient, and environmentally sound. Sensata serves numerous industries; from automotive to aircraft to appliances to telecommunications. We are one of the world's leading suppliers of sensors, electrical protection, and power management solutions.

Our work is "inside the black-box" at the intersection of mechanical engineering, electrical engineering, and business disciplines. We turn physical phenomena (e.g., pressure, temperature, acceleration, position, speed, current, humidity, etc.) into electrical signals using a wide variety of technologies and materials. Sensata specializes in "mission critical" products that must function properly (often in harsh conditions) to control essential systems related to automotive brake performance, engine emissions, solar panel safety, and refrigeration efficiency, to name a few.

Reporting to a design engineering manager, the Product Design Engineer is responsible for the full product life cycle [initial customer contact, technology selection, conceptual design, supplier and process inputs, detail design, cost optimization, prototyping, development testing, qualification testing, production launch, tear-down analysis, customer technical support, and continuous improvements]. Sensata engineers take on a great deal of responsibility very quickly, and they succeed with the mentoring and guidance of more experienced colleagues. Sensata's culture is collaborative; global, cross-functional teaming is the norm.

Responsibilities

- apply core engineering concepts to solve complex, unfamiliar, and novel problems
- clearly and concisely communicate complex information to peers, managers, and customers
- take initiative and think creatively
- overcome obstacles and tenaciously drive to achieve goals
- achieve results with teams, as a colleague and as a leader

Requirements

- hand's-on fabrication and assembly
- prototyping, testing, and troubleshooting
- mechanical design and drafting including 3D CAD (we use Solidworks)
- proficiency with data analysis tools (e.g., Excel, Matlab, Minitab, etc.)
- knowledge of basic electrical circuits, and microelectronic assembly
- familiarity with manufacturing methods (e.g., welding, soldering, adhesive bonding, machining, stamping, molding, etc.)
- finite element analysis fundamentals
- process control and six-sigma techniques
- basic material properties and material selection criteria
- B.S., M.Eng., or M.S. in mechanical engineering (from an accredited program, completed prior to start date).
- 3.0/4.0 grade point average minimum.
- 0-3 years of industry experience.
- U.S. citizen or U.S. permanent resident is required for this position unless you have an M.Eng/M.S or above

swarovski crystal: design engineer[58]

Description

The Design Engineer will design and develop products which meet the design/marketing requirements with an efficient design to manufacture. They will create and manage project plans using the Swarovski Lighting Stage Gate Process and may manage one or more projects.

Responsibilities

- manage his/her own project plan for one or more projects
- develop prototypes of products by evaluating design and marketing requirements.
- obtain prototype approval by developing revised prototypes based on design and marketing feedback.
- introduce new product designs into production by completing design drawings, tooling drawings and facilitating release process throughout organization.
- ensure that the designs are both accurate and cost effective.
- keep up to date on Certification requirements of product designs.
- complete quality product designs that adhere to all regulatory standards for region product is being marketed in.
- modifications of existing designs as required
- ensure timely releases to production adhering to established engineering/production schedule for that project.
- complete both Standard product and/or Project product designs as required by workload.
- provide ongoing direction and support to Engineering and Production on assigned design products

Requirements

- Bachelor's Degree in Engineering is preferred. Associate's Degree in Industrial Technology is accepted.
- 1-3 years work experience.
- CAD experience, NX a plus
- Working knowledge of Microsoft Office

deloitte: visual design consultant[59]

Description

Deloitte is defining the digital landscape. We are pioneering a new model for a new digital world. Do you like to challenge the status quo? Does curiosity feed your soul? Are you addicted to the thrill of creating? Do you want to be your authentic self at work? Then consider a career at Deloitte. Creative design, state-of-the-art technology and your imagination merge here to create lasting impact for our clients. Not to mention make for a pretty fun and meaningful career.

Responsibilities

- The Design Consultant works as part of Doblin + Customer Strategy & Applied Design's innovation delivery teams to collaboratively define new future business concepts and new product/service/system offerings, including conceptual direction and formal expression, under the direction of a project manager or more senior designer.
- This individual will be expected to demonstrate primary interest and experience within the design practice, and also bring a client-facing skill set required to execute innovation consulting projects.
- Day-to-day work will include working with a multi-disciplinary set of colleagues and contributing heavily to the design process throughout client casework.
- Internally, Design Consultants are responsible for contributing to the development and communication of principles, methods and intellectual property related to Doblin + Customer Strategy & Applied Design's design capability, sometimes to audiences of non-designers.

Requirements

- Design and develop client communication materials and client events (overall experience, supporting assets and artifacts, etc.)
- Support client engagement and internal teams in the exploratory development and iterative processes.
- Define visual direction for of new offerings and businesses.
- Co-lead concept prototyping and evaluative testing of new concepts
- Support business development and proposals for new client work
- Contribute to internal research and development projects
- Provide feedback, support and mentorship to more junior design team members

trip advisor: junior visual designer[60]

Description

TripAdvisor provides a unique, global work environment that captures the speed, innovation and excitement of a startup, at a thriving, growing and well-established industry brand. At TripAdvisor, you will be part of a dynamic, fun, and energetic team where you can immediately make meaningful contributions.

Ready to play an important role at TripAdvisor, the world's largest travel site? You'll be part of a dynamic and collaborative environment that fuses the speed, innovation and excitement of a start-up with the stability and resources of a global industry leader.
We're looking for a Junior Visual Designer to support of our B2C efforts and grow/enhance the brand experience for millions in the TripAdvisor community worldwide. You will be involved in the creation and execution of unique deliverables across multiple touchpoints - web, mobile, email, print, social, out-of-home, and beyond…

To succeed in this role, you'll leverage your passion for making design decisions that drive consumer and owner behaviors on a wide range of projects spanning print and digital experiences. Must embrace a fast-paced environment, remain calm under pressure, able to manage multiple projects at once, and execute on the direction and requirements of these projects.

In short: Awesome brand. Global audience. Collaborative environment. Cool teams. Free lunches. Dog-friendly. Design & influence for a living.

Responsibilities

- Work with the Brand Creative Team (Designers & Copywriters) to maintain a consistent aesthetic across all marketing materials and touchpoints, including emails, digital ads, banners, landing pages, social media posts, templates, campaigns, event graphics, videos and more across global points of sale
- Support the Brand Creative Team with design production and localization efforts.
- Partner with and take direction from senior members of the Brand Creative Team to translate business needs/goals into design solutions and consumer facing design deliverables.
- Support presentation/pitch deck needs across CoreX
- Help to maintain and enforce the TripAdvisor Brand Book, templates, style guides, and toolkits across all relevant touchpoints of the brand.

Requirements

- Strong online portfolio featuring examples of digital and print work
- Bachelor's Degree in Graphic Design or other related accreditation to an Arts College or University
- 1-2+ years' experience in the creative field. Agency and in-house brand/marketing experience a plus.
- Capable working in a fast-paced, high-volume work environment.
- A passion for travel, design and creative expression.
- Experience with direct response campaigns, including (but not limited to) digital ads, email and social media.
- Knowledge of social platform assets, best practices, and trends, and design of social assets.
- Capable of taking direction/feedback and translating it into final creative deliverables.
- Solid understanding of design principles and best practices (e.g. typography, color theory, layout, information hierarchy).
- Ability to present and articulate design solutions/ rationale to the creative team and project stakeholders.
- Ability to quickly communicate ideas through sketching, whiteboarding and storyboarding
- Proactive communicator.
- Strong organizational skills.
- Keen attention to detail.
- Team player.
- Intermediate proficiency in Adobe Creative Suite (specifically Photoshop, Illustrator, and InDesign)
- Intermediate proficiency in Sketch and paired plugins (Zeplin and Craft)
- Intermediate proficiency in presentation/pitch software (Keynote, Powerpoint and Google Slides)
- Experience with prototyping software (Invision)
- Illustration chops a huge plus but not a requirement.
- Video and motion design abilities a plus

clarke valve: design engineer[61]

Description

Clarke Valve™ is seeking a Design Engineer to join their energetic team of engineers at the corporate headquarters located in North Kingstown, RI. As a Design Engineer you will use specialized software to create drawings & models and maintain engineering records of new and existing products based upon project scope requirements. This role is part of a project team that is tasked with completing a project from inception to product launch.

Responsibilities

- Participate in all aspects of engineering design and development, from conceptual design backed by detailed calculations and peer design reviews, to prototype fabrication.
- Create 3D models and manufacturing drawings of valve components and assemblies using SolidWorks.
- Design Validation Testing: design test fixtures, develop test plans, analyze test data, and prepare test reports.
- Participate in design reviews and ensure engineering governance is in place.
- Perform simulations (FEA/CFD) to validate new and existing designs.
- Work closely with project team members and

other company functions to ensure compliance with project requirements.
- Ensure components and assemblies adhere to company and customer standards and requirements.
- Be able to represent the Clarke Valve™ project team, communicating with other internal functions and team members with respect to engineering issues.
- Promote the problem-solving company culture.
- Follow the Clarke Valve™ policies and procedures.

Requirements
- Have an open mind and be flexible to changing requirements
- At minimum the candidate shall have a Bachelor's Degree in Mechanical Engineering, Industrial Design, Materials Engineering or equivalent.
- Knowledge of how a Phase Gate process works within an organization is desirable.
- Understanding of valve industry standards (e.g., ANSI, ASME, B16.34, B16.10, API, ANSI, ISO).
- Familiarity with valves and actuation used in aerospace and industrial applications.
- Strong working knowledge of ISO 9001.
- SolidWorks (CAD, Simulation, PDM, CAM), Microsoft Office (Word, Excel, Project, PowerPoint), COMSOL
- Strong knowledge & experience with SolidWorks 3D CAD software.
- Working knowledge of drafting standards, including Geometric Dimensioning & Tolerancing (GD&T) and tolerance analysis.
- Experience creating 3-D models and manufacturing drawings using SolidWorks.
- Experience with finite element analysis (FEA), multi-body dynamics analysis, computational fluid dynamics (CFD), or thermal analysis.
- Understanding of manufacturing processes (e.g., casting, machining, forging) and ability to work with suppliers.
- Ability to competently use Microsoft Office applications (Word, PowerPoint, Excel, Project). • Ability to work in a 5S/6S environment.
- Capable of setting tasks that will achieve the project goals and are completed on time.
- Organization and time management skills, with the ability to multi-task and manage competing priorities.

what is a successful designer?[62]

Alex Lo described what was crucial to becoming a successful designer and what he would look for in an applicant:

> **"What is crucial in becoming a successful designer is the ability to balance thinking outside of the box while methodically approaching the design process. While the design process requires creativity, it is still a process that is based around the user and based on achieving tangible solutions that can be iterated upon in the future. If I were to hire someone, I'm looking for someone who can apply the design process beyond the scope of product and visual design. I'm looking for someone who uses the design process as a problem solving process-- designing good code is very similar to designing effective visuals and to designing manufactured products. I am looking for someone who has technical knowledge, who is willing to learn on the fly, and whose mindset has a solid foundation in the design process."**

4. ADVISING RESEARCH

BEO advising

The BEO concentration has 3 different tracks: Organizational Studies, Economics, and Entrepreneurship & Technology Management. There is one advisor for students in the Organizational Studies track. Economics and Entrepreneurship & Technology Management each have two advisors. "Each student is assigned a [track] advisor with whom they meet on a regular basis once they formalize their BEO Concentration."

The BEO concentration is popular. The Class of 2018 had 95 students graduate with a degree in BEO. Because students declare their concentration in the Spring of their second year, there are at least 190 BEO concentrators at any given time. For 5 advisors, this is a heavy advising load. Advisors are supported, in part, by the BEO DUG (Department Undergraduate Group). The DUG "plans programs in conjunction with BEO faculty and staff to foster a sense of community within BEO. DUGs help students make and strengthen connections with other concentrators, professors, and concentrator alums."

Because BEO is not a department at Brown, a faculty committee "comprised of representatives from the Economics, Sociology Departments and the School of Engineering oversees the BEO concentration and recommends course credit requirements and academic policies for the concentration to the College Curriculum Council." The BEO faculty committee consists of 9 representatives, of which 4 are also Concentration Track Advisors.

behavioral decision sciences advising

For Behavioral Decision Sciences, there is one concentration advisor, Professor Steven Sloman of the CLPS department. However, Behavioral Decision Sciences also has numerous Area Specialists for each of its five affiliated departments (CLPS, economics, philosophy, computer science, and political science). There are a total of 11 area specialists, not including Professor Steven Sloman.

Concentration Advisor

Steven Sloman *(CLPS)*

Area Specialists

Oriel FeldmanHall, Michael Frank, Joachim Krueger, Amitai Shenhav *(CLPS)*

Geoffroy de Clippel, Kareen Rozen, Pedro Dal Bó *(Economics)*

James Dreier *(Philosophy)*

Amy Greenwald, Michael Littman *(Computer Science)*

Rose McDermott *(International and Public Affairs, Political Science)*

5. BDW COURSE INTEGRATION

As mentioned above, most faculty agreed that the Brown Design Workshop's strength lies in increasing accessibility to various aspects of the design process through the equipment and expertise of students and staff. There are few courses that successfully interact with the space, such as Introduction to Engineering (ENGN0030) and Design Studio (ENGN0930C). Nevertheless, there are several departments that can be reinforced through collaboration with the space by giving their students a chance to learn hands-on skills, as well as the creative and visualization components of Design. A sample of these departments are listed below, along with courses that show a potential for integrating the BDW into their class agenda.

University Courses
- The Theory and Practice of Problem Solving

Assyriology
- Thunder-gods and Dragonslayers: Mythology + Cultural Contact

Visual Arts
- Studio Foundation
- Foundation Media: Sound and Image
- 3-D Foundation
- Investigating Collage
- Sculpture: Material Investigations
- Junior/Senior Seminar in Visual Art
- Lithography
- Sculpture II: Conceptual Propositions

History of Art and Architecture
- Intro to Arch Design Studio
- Architecture, Urbanism and the African Diaspora
- Prefabrication and Architecture

6. COURSE CREATION - HACKING FOR DEFENSE

Hacking for Defense is a course that was developed by Steve Blank at Stanford in 2016. In Hacking for Defense, teams of students solve problems that the Department of Defense or another government organization have flagged as important. Working alongside sponsor organizations, teams solve problems knowing that their solution has the resources and support to be meaningfully put into practice.

The course is taught with a methodology which mirrors the workflow of both a designer and engineer. The team must first understand the problem from the user's point of view. Then, they rapidly prototype a solution, go back to all stakeholders to ask questions and receive feedback, and repeat this process until a minimum viable product matches the user's needs within the project's constraints. Matching needs within constraints is an idea that consistently came up in surveyed faculty members' definitions of design.

At Brown, when engineers are looking for hands-on projects, many turn to extracurriculars, such as Brown Space Engineering or Brown Formula Racing. Hacking for Defense would be a unique and valuable experience, as it provides a rigorous academic environment alongside real projects that solve real problems. One of the teams at USC developed a fleet of "tiny, cheap, synthetic aperture radar satellites that may prove instrumental in tracking missiles launched by North Korea".[63] Examples of other projects include Non-Intrusive Load Monitoring for the Department of Energy and Knowledge Management for Analysts for the CIA.[64]

Following the course's success at Stanford, other peer institutions quickly adopted it. This academic year, 20 universities are teaching Hacking for Defense, including Columbia, Duke, and Johns Hopkins. While the course is typically taught out of the university's Engineering or Computer Science department, not all problems are necessarily technological. Some of the sponsor's problems may be policy-oriented or diplomatic in nature. John spoke to Jason Cahill, one of two professors who teach the class at Columbia. Cahill said that each semester Columbia is presented with a dozen sponsor problems. He and his teaching assistant then select 5 based on anticipated student interest and skills. The ability to choose sponsors projects allows each university to align projects with its strengths and values.

The rapid adoption of Hacking for Defense has been made possible by H4Di, a non-profit which supports Hacking for Defense courses: "H4Di is the focal point for problem generation, vetting, and validation of government programs. All problems sourced to Hacking for Defense… will go through H4Di's vetting process before being made available for selection by student teams".[65] H4Di scopes all the projects to ensure that they will be worthwhile and completable within a semester.

H4Di screens the primary and secondary points of contact at the sponsor organization. This ensures that teams will have a sponsor who is not only responsive but also capable of putting the team's project into action. Each team is expected to have a total of 10 calls with stakeholders (users, experts, partners) every week. The sponsor organization acts as an "interview broker' to help set-up calls for the team.[66]

When the semester starts, teams of 4 or 5 students are formed. Professor Cahill found that one professors could comfortably manage a class with 6 teams. He also found the most successful teams to be primarily upperclassmen.

Teams are then assigned one of the professor's pre-chosen problems based on each team's skills and interests. H4Di connects each team with a set of 10 calls with key stakeholders. After projects are established, the class follows a weekly flow, outlined below:

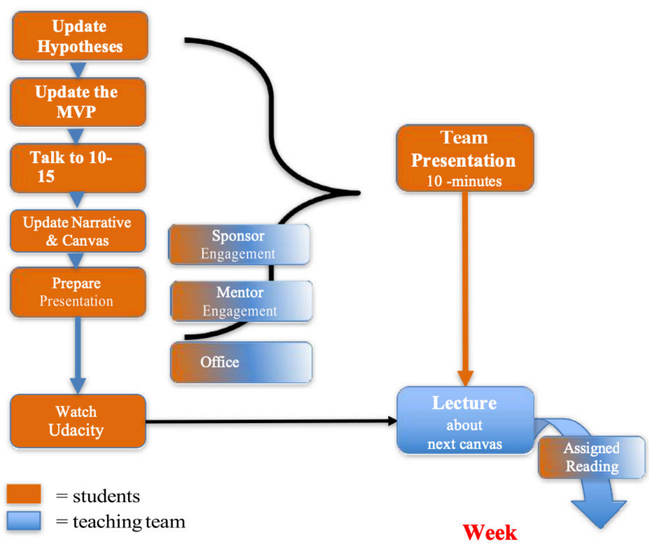


Figure I: H4Di course outline.

Traditionally, the class meets once per week. Between classes, students complete the tasks going down the column from update hypothesis to watch Udacity. This is a rigorous course load and other universities advertise a workload of 10 to 15 hours each week. By watching Udacity videos, all lectures take place outside of class. Steve Blank, the course creator at Stanford, has recorded eight 30-minute class lectures, each with quizzes to confirm understanding. Blank has written best-selling books on entrepreneurship and is considered a leading Silicon Valley thought leader.

Because the classroom is flipped and there is substantial support from H4Di, there is a low barrier to organizing and teaching Hacking for Defense. Training materials educate the faculty member and outline how to get the course off the ground. These materials include outlines for each class session, team-forming exercises and everything else, down to the smallest detail. Professor Cahill (Columbia) raved to John about the teaching materials and how well-prepared he felt to lead the class.

Hacking for Defense would complement the BDW and fill a hole in the Engineering curriculum. The BDW is largely underutilized by Engineering courses. However, students in Hacking for Defense would use it heavily. NextFlex, a H4Di sponsor, "provides a funding mechanism that [allows] Problem Sponsors to provide financial support to team prototyping efforts.[67]

Additionally, within the School of Engineering, there is already a precedent of successfully adopting Steve Blank's courses. Professor Rick Fleeter teaches a Wintersession course called, "Lean LaunchPad." The Lean LaunchPad methodology was developed by Steve Blank, the same Stanford professor who developed Hacking for Defense. The methodology teaches empathetic problem solving and rapid prototyping, the foundation of the Hacking for Defense course. These skills are core to both being a successful designer and a successful engineer. Experiences to build those skills are difficult to come across. Therefore, it would be prudent to bring Hacking for Defense to the School of Engineering, with the first course being taught next Fall.

7. OUR DESIGN SPRINT

As a major component of this DISP, we took a day and ran a mini design sprint to share all of the knowledge we had collected, and finalize the direction we were going in. Typically, a design sprint is a five-day process that uses design thinking principles to research, ideate, prototype, and iterate upon a problem that a business or company faces. We used the design sprint framework to compile all of the research the groups collected, see where there were common threads, and outline the final proposal.

The sprint was conducted on November 3rd, 2018. The sprint session came from IDEO's Design Kit. The schedule for the day is below:

9:30 - Bagels + Prep
9:45 - Sprint Overview + Expectations
10:00 - Understanding Our Personal Biases

Everyone came into the DISP with their own ideas of what design is and what the proposed curriculum should look like. The goal of this exercise is to explicitly address everyone's goals/desires/want/needs when it comes to design in order to operate more effectively as a group. We will answer questions such as:

- Why did I join this DISP? What do I want to get out of it?
- What kind of design am I focused on? What is my ideal curriculum?
- What are my concerns? (regarding the DISP, SOE, Design+, etc.)
- And everything else that is on our minds

We will then card-sort the notes we generate into groups to see where everyone's thoughts sit

11:00 - Downloading Our Learnings Pt. 1

This is where we are going to compile all of our research, data, quotes, thoughts, observations, responses, + notes from throughout the DISP regarding the curriculum and design onto sticky notes so that everyone can see the knowledge that has been collected so far. This task will be done in research groups, so try to come with any individual notes already prepared.

12:00 - Lunch
12:45 - Bundle Ideas

In response to Downloading Our Learnings, we're going to on creating curriculum ideas that addresses the information we have found so far. However, we aren't going to try and address all problems/ideas immediately. We are going to start with specific answers to the problems we've identified, and work our way up to a final solution by pulling from the best elements of these mini-solutions.

1:30 - Determine What to Prototype

Based off the findings create mocks of the curriculum plan + a have a thorough understanding of how it works, and come up with strategies that we could use to test components of the curriculum

2:00 - Downloading Our Learnings Pt. 2

This is an extension of the first Downloading Our

Learnings where we are essentially going to add to the Post-Its we've already generated. This session is specifically centered around the proposal and its structure, outline, content, etc.

2:45 - Break

3:00 - Find Themes

The goal is to understand where people's thoughts and perspectives lie surrounding the proposal are aligning and to consider any aspects that may have been missed up until now. This is also an opportunity to start discussing tangible aspects of the proposal, such as structure and format + how we'll address that moving forward.

3:30 - Create Frameworks

Use visual diagramming methods to organize the thematic structure + outline possibilities for the final flow of the proposal.

4:00 - Storyboarding

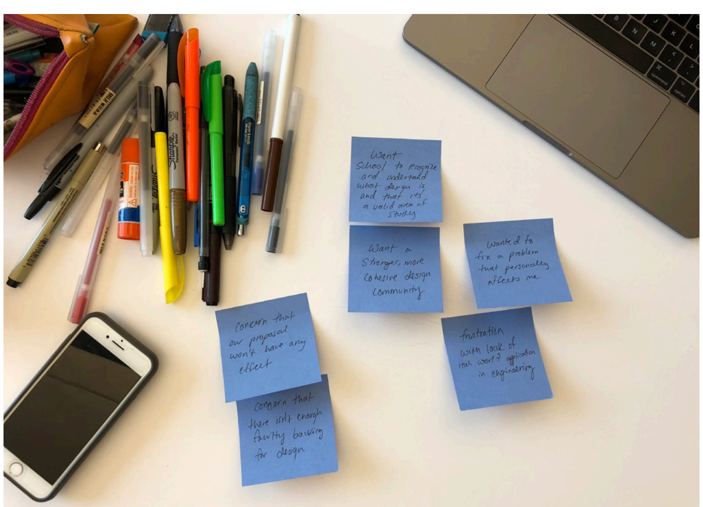
This is not going to be like traditional storyboarding where we diagram out someone using our final product. Instead, this is going to focus more on the arguments we'll be making throughout the proposal, and how those "look" to interested parties, such as faculty, administration, and students.

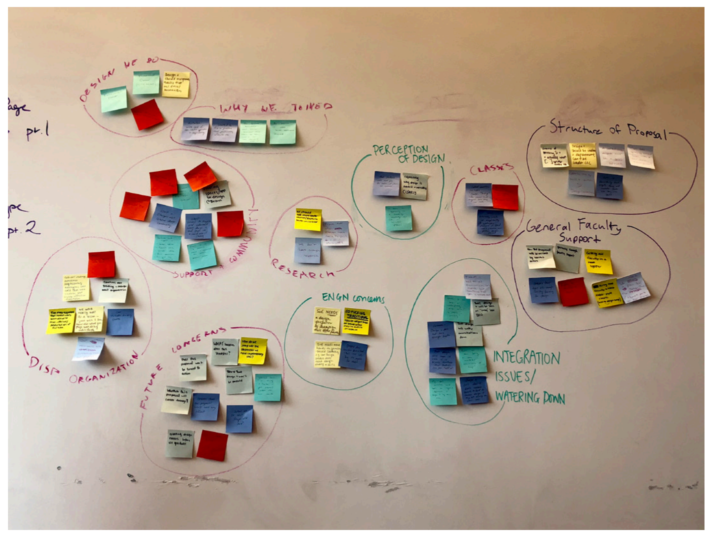
4:45 - Break

5:00 - Roadmap + Define Success

This is the stretch - almost done with the day! Now we are going to outline the measures (both short and long term) that we'll use to determine "success." Using these definitions, we're going to create a strategic timeline that specifically outlines key dates + milestones for the rest of the semester, but also our plans for the future.

5:30 - Wrap-Up + End





8. SAMPLE DESIGN+ BA FOUR YEAR PLAN

I	Intro to Design*
	ENGN 0030: Introduction to Engineering
	MATH 0200: Intermediate Calculus
II	Sample Design class
	ENGN 0040: Dynamics and Vibrations
	General Science
III	Overlapping class
	Sample Engineering class
IV	Sample Design class
	Sample Engineering class
V	Sample Design class
	Sample Engineering class
VI	Sample Design class
	Sample Design class
	Sample Engineering class
VII	Capstone
	Sample Design class
	Sample Engineering class
VIII	Sample Design class
	Sample Engineering class

classes that fulfill Design+ requirements
classes that fulfill ENGN A.B. requirements
classes that overlap requirements
electives

GLOSSARY

This glossary is meant to assist the terms used in this proposal that have specific definitions or merge various ideologies.

Accessibility[68,69] - Users' ability to use products/services, but not the extent to which they can attain goals, which refers to usability.
Additive knowledge[70] - Students incrementally map new ideas onto old ones, or conceptual thinking in which students eventually revise and build their own their structures for understanding a concept.
Aesthetics[71] - A set of principles concerned with nature and appreciation of beauty, can also involve the application of such principles to achieve a desired outcome.
Architectural design - Any man-made building or structure designed to express ideas
Biomimicry[72] - An approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies.
CAD/CAM[73] **-** Computer Aided Design or Computer Aided Manufacturing; a process that uses various softwares, tools, and machines to prototype ideas.
Creativity[74] - The use of the imagination or original ideas.
Defined problems[75] - Problems that are well articulated and often have defined processes needed to solve them; a problem with specific goals and clear expected solutions
Design - Referring to the field of Design within the proposal (as a noun).
design - Referring to the practice or act of creation with intention in the proposal.
Design Theory[76] - The philosophy or ideology behind design practices; tries to describe or explain design activity.
Design Thinking/Process - The practice of design; iterating and testing through continuously examining aims and incorporating user feedback in meaningful ways.

- Design thinking: A process for creative problem solving (IDEO[77])
- Design thinking: Empathize, Ideate, Define, Prototype, Test (d.school[78])

Empathy[79] - How we understand people; the effort to understand the way people do things and why, their physical and emotional needs, how they think about world, and what is meaningful to people.
Engineering Design[80] **-** (as according to ABET) engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to optimally convert resources to meet a stated objective.
Graphic design[81] - Graphic design, also known as communication design, is the art and practice of planning and projecting ideas and experiences with visual and textual content. The form it takes can be physical or virtual and can include images, words, or graphics.
Human Centered Design[82] - A philosophy that empowers an individual or team to designing products, services, systems, and experiences that address the core needs of those who experience a problem.
Innovation[83] - A process that involves multiple activities to uncover new ways to do things. It should not be confused with creation since this can be defined as the act of making, inventing, or producing something.
Intangible skills[84] - Generally categorized as interpersonal and communication skills, sometimes compared to emotional intelligence (EQ); which fall into the domains of self-awareness, self-management, social awareness, and relationship management.
Interaction design[85] - Defines the structure and behavior of interactive systems.
Iterative design[86] - Process of designing a product in which the product is tested and evaluated repeatedly at different stages of design to eliminate usability flaws before the product is designed and launched.
Product[87] - A result of an iterative development process that can tangible or intangible.
Product development[88] - Refers to all of the stages involved in bringing a product from concept or idea, through release and beyond.
Prototyping[89] - A digital, physical, or diagrammatic way of communicating ideas.
Rapid prototyping - Used to create a three-dimensional model of a part or product either digitally or physically. Rapid prototyping can be used to test the efficiency of a design and is usually more cost-effective than creating a full fidelity, full scale model.
Rigorous research[90] - (in a general design and engineering design context) Research that involves in-depth qualitative and quantitative research; applies the appropriate research tools to meet the stated objectives of the investigation.
Signal processing[91] - (mostly exists in an engineering design context) An area of engineering and mathematics that analyses and operates on the signals in order to enhance the representations of physical or electrical parameters/properties of the signal.
Storytelling[92,93] - A sequence of events that tries to map out the user journey via a set of actions and events. Allows designers to think about the context and entire range of factors that will be in play with their designed creation.
Sustainable design[94] - Sustainable design is the intention to reduce or completely eliminate negative environmental impacts through thoughtful designs.
Systems design[95] - System design is the process of defining the components, modules, interfaces, and data for a system to satisfy specified requirements.
Usability[96] - the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.
User experience design[97] - UX design is the process of designing (digital or physical) products that are useful, easy to use, and delightful to interact with.

User interface design[98] - Design of user interfaces for machines and software, such as computers, home appliances, mobile devices, and other electronic devices, with the focus on maximizing usability and the user experience.

User Research[99] - Conducted so as to understand users' characteristics, aims, and behaviors towards achieving these aims. Involves the continuous evaluation of the impact of designs on the users, more commonly during the design and development phase but also in the long-term phase as well.

Tangible skills[100] - Specific abilities that can be measured and defined, for example using software programs, handling tools, or even typing.

Testing[101] - The practice of taking user feedback and using ways to measure them against specifications, constraints and goals laid out.

Various definitions of thinking

Convergent thinking[102] - A problem solving technique involving the bringing together different ideas from different participants or fields to determine a single best solution to a lucidly defined problem.

Divergent thinking[103] - The strategy of solving problems characterized by a multiplicity of possible solutions in an attempt to determine the one that works. Usually happens in a free-flowing, spontaneous manner.

Integrated/integrative thinking[104] - The ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other.

Lateral thinking[105] - A solution-oriented set of techniques which aim to re-frame a problem by highlighting new associations and relationships that may not be clear when a problem is approached through step-by-step problem solving.

Liminal thinking[106] - A way of thinking that practices the art of creating change by understanding, shaping, and reframing beliefs.

Systems thinking[107] - A set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects.

Whole brain thinking[108] - Engaging both left-brain thinking (analysis, logic, synthesis, math) with right-brain thinking (intuition, metaphorical thought, creative problem solving).

T-shaped[109] - (learning/person) A framework of learning that has both breadth and depth. The vertical stroke of the "T" indicates the depth of skill, whilst the horizontal stroke of the "T" indicates collaboration across disciplines.

Wicked problems[110] - A social or cultural problem that is difficult or impossible to solve for as many as four reasons: incomplete or contradictory knowledge, the number of people and opinions involved, the large economic burden, and the interconnected nature of these problems with other problems.

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