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USING "WHY AND HOW" TO TAP INTO NOVICE DESIGNERS' METHOD SELECTION MINDSET

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ABSTRACT

Despite the growing utilization of human-centered design, both in academia and industry, there is lack of pedagogical materials that support context-based design method selection. When used properly, design methods are linked to successful outcomes in the design process, but with hundreds of design methods to select from, knowing when and how to use a particular method is challenging. Selecting the appropriate design method requires a deep understanding of the project context. Cultivating a selection methodology that is more contextually aware, equips students with the tools to apply the most appropriate methods to their future academic and industry projects. Using *theDesignExchange* knowledge platform as a teaching material, we discuss a summer design course at the University of California at Berkeley that encourages students to choose design methods rather than the instructors giving a set list. The findings illustrate that when given the task to select a method, students exhibit contextually-aware method selection mindsets.

1. INTRODUCTION

1.1 Design Education, Methods, and Context

Dym et al. review the history and the role of design in engineering education, emphasizing the importance of Project-Based Learning (PBL) driven new product design processes [1]. New Product Development (NPD) courses are now offered at both undergraduate and graduate levels across a number of U.S. universities [2]. The generic NPD process follows four distinct iterations of observations, frameworks, imperatives, and solutions [3]. Embracing a human-centered design process, the students engage in needs finding, problem framing, concept generation, concept development, prototyping, testing and concept refinement. To support the instruction of human-centered design in the classroom, there has been a rapid growth of educational materials [4, 5, 6, 7].

Introduced in the early 1960s, a design method is a structured procedure that supports specific actions within the design process [8]. The usage of design methods has been linked to successful outcomes in the design process, when properly applied [9]. Many industry practitioners, educators, and researchers have introduced various design methods and to date, there are over 300 distinct design methods [10]. With so many options, however, knowing when and how to deploy a design method during the design process can be challenging [11]. Proper selection and execution of a design method requires an understanding of the project context [12, 13]. As highlighted by Andreason, "Methods belong to a context, which makes the actual application meaningful. Methods' execution builds upon an interpretation of the reality and the practice they shall operate into." [14].

The exact definition of "context" remains underexplored. Gericke claims that "in order to apply a method properly, one must first understand the context-specific sociotechnical interrelations of the method." The term sociotechnical refers to the complex interaction between human behavior, technology, and complex infrastructures intrinsic to our society, tying context to both a specific industry domain and user base [15]. Chakrabarti claims that the "context (design stage, activity, etc.) of use of the method and expected benefits of using the method should be clear to the user" during selection of appropriate methods [16]. By aligning the context of a design problem to a

specific method, it can be determined if a specific method should be selected and applied in a given situation.

1.2 Challenges of Teaching Methods in Context

Despite the increased growth of human-centered design (HCD), Project-Based Learning (PBL), and New Product Development (NPD) courses, current teaching resources such as textbooks and static web repositories limit students' ability to understand context-specific application of design methods [12].

Textbooks and other printed publications tend to delve into a set of methods in relation to a specific discipline, written by domain experts in a cohesive and consistent manner and contain quality descriptions and instructions to guide the execution of methods. However, they provide limited help in understanding the questions that need to be asked to ascertain contextual appropriateness. While web repositories containing design methods add interactive features such as search capabilities, linking of similar methods and relevant supplemental materials, and providing templates to help execute certain methods, they too provide limited support in helping novice designers and students select a method to apply to practice within a specific use case or context [12]. The curriculum of many design courses that use these textbooks and static web-based repositories to teach design thus introduce and prescribe only a small subset of methods, thereby limiting the breadth and diversity of method selection for students to apply in practice.

1.3 *TheDesignExchange*

TheDesignExchange (tDX) is the world's largest open-source innovation archive of design methods (300) and case studies (>80). Unlike traditional textbooks and static web repositories, *TheDesignExchange* (theDesignExchange.org) provides a collaborative space for design practitioners to discuss and share their design knowledge and experiences. It was meant to develop a web that allows novice designers and students to gain an understanding of how design methods are applied to specific contexts via case studies. Each method and case study contain comprehensive information that supports context-specific method usage (Annex A). To date, *TheDesignExchange* has been used as an online textbook in new product development courses, both at a graduate and undergraduate level at UC Berkeley, MIT and other colleges and universities.

Motivation

Usage of *TheDesignExchange* in the classroom provides an opportunity for students to execute selected methods that specifically align with their project context. Rather than prescribing a set list of methods to students, instructors can curate and present a larger collection of methods for students or teams to select from. By empowering students to critically choose appropriate design methods to execute, they will be better equipped to apply the most appropriate methods to their future academic and industry projects.

The research questions we address in this paper are:

Q. What factors do individuals and teams consider (context) in choosing certain methods and why do they think their choices are appropriate for tackling their design challenge?

Q: Which context characteristics were mentioned in method selection?

Q: During which phases are students' engaging in contextual awareness?

2. RESEARCH DESIGN

2.1 Test Bed: Design Thinking: Methods, Skills, and Mindset (DesInv. 390-001)

The summer Design Thinking course took place at UC Berkeley in early July 2017 to August 2017. The student teams – twenty-seven students in six teams – worked on a 'reimagining mobile sensing' design challenge over a six-week-long course that covered the design thinking process developed by *theDesignExchange* (theDesignExchange.org) [10]. The course was organized around five design thinking modules: Research, Analysis, Ideate, Build, and Communicate. Students used *TheDesignExchange* as an online textbook to learn a variety of design methods in accordance with the course curriculum and a design challenge. The course description is provided below.

Course Description

The goal of the Design Thinking course is to learn principles and methodologies of human-centered design, and product development in a real-world context. As most design and engineering professionals work under tremendous time pressure and do not have an opportunity to reflect on the development process, this course was designed for students to allow time to experiment, reflect and learn before their professional employment. Teams of four-five students had the opportunity to work with students from multiple disciplines.

2.2 Demographic of participating students in the design challenge

Twenty-seven students from different demographic backgrounds were enrolled in the class to address the given cybersecurity design problem.

- Gender: 15 males and 12 females
- Nationality: 14 domestics, 15 internationals
- Majors: 12 engineering, 4 architecture, 4 cognitive science, 1 economics, 2 business, 1 mathematics, 3 letters & science
- Year in: 16 upper-levels (senior or junior), 11 lower-levels (freshman or sophomore)

2.3 Course Structure

Rather than requiring that students use specific design methods, they were given a list of design methods (Table 1) and were asked to select their top three choices from that list both individually and as a team. Students were assigned and expected to read each method of the corresponding module from theDesignExchange prior to every class. Each method was discussed in class in a similar manner (one-slide overview) for

roughly the same amount of time, to minimize bias in students' selection or knowledge of the method collection. Students were not explicitly taught to use methods based on context and were not required to use a particular method.

However, the one-slide overview per each method did include the following information, which may have informed their contextual understanding: synonyms, materials, needed, usage, and characteristics.

Table 1: METHODS COVERED IN 5 MODULES

Modules	Methods Covered
Module 0: Introduction	Design Journal
Module 1: Research	AEIOU, POEMS, POSTA, Closed Card Sorting, Open Card Sorting, Design Ethnography, Focus Group, Community Appraisal, Conversation Café, Competitive Analysis, Conjoint Analysis, 1:1 Interview, User Observation, Usability Testing
Module 2: Analysis	Why-how Laddering, Empathy Map, Spectrum Mapping, 2x2 Matrix, Reframing, Powers of 10, Customer Journey Mapping, How Might We, Mind Map, Context Mapping, Affinity Diagramming, Atomize, Concept Map, Touchpoint Matrix, Task Analysis, and Kano Analysis
Module 3: Ideate	6-Up Sketches, Visual Brainstorming, Brainstorming, 3-12-3 Brainstorming, 6-3-5 Brainwriting, Attribute Listing, Do-Redo-Undo, Biomimicry, Weighted Matrix, Forced Analogy, Design Heuristics, The Anti-Problem, Borda Count Voting, Design the Box
Module 4: Build	Live Prototyping, Wireframe, Rapid Prototyping(New), Laser Cutting, Water Jet Cutting, Direct Shell Production Casting, Laminated Object Manufacturing, Fused Deposition Models, Tangible Prototype, Experience Prototype, Service Prototype, Additive Manufacturing
Module 5: Communicate	Envisionment Videos, Storyboards, Service Blueprint, Business Model Canvas, 7 Ps Framework, Usability Report, Personas, Composite Characters, Design Roadmap

2.4 Data Collection

A total of 15 surveys were collected throughout the course. Students were asked to complete three surveys per each module (beginning, mid, and end of each week). A survey at the beginning of the course was developed to understand what methods individuals would use in their team projects before they were covered in the regular lectures. Administered online, it asked participants for specific reasons why/how they decided to select certain methods amongst the listed methods in the Table 1, the course syllabus. Three sets of individual and team surveys were repeated over the six weeks. The teaching team monitored and examined the results of their responses in weekly team deliverables. Sample prompts of three weekly surveys to the class are included in Annex B. Each teaching team member reviewed the results of two teams and provided weekly written and/or oral feedback. Table 2 provides a brief overview of the teams' diverse final solution sets.

Table 2. OVERVIEW OF CONCEPTS AND THEIR DESCRIPTIONS: DESIGN CHALLENGE IN REIMAGINING MOBILE SENSING

Team #	Concept Description
1	An automatic trash disposal machine aimed at simplifying the lives of undergraduate students and leaving them more time to devote to their studies.
2	A medical box that can send data and real-time feedback to the doctors and family members to help you on track develop a solution that can not only remind a patient to take drugs but also serve as a way to keep people connected.
3	A solution to connect students instantly to campus, community, and social resources through eliminating the existing psychological and structural barriers with mobile sensing and crowd-sourced data.
4	An augmented reality (AR) safety network that utilizes the existing framework of street lamps to increase safety and security through smart navigation.
5	An app to enhance the experience of Bay Area Rapid Transit (BART) users who regularly rely on BART to commute to their destinations by providing, among other things, user-tailored information about stops and departure/arrival times.
6	A solution to automate and simplify the process of detecting and extinguishing fire to ensure users' safety while preventing loss of users' possessions.

3. DATA ANALYSIS

The teaching team consolidated all students' surveys (individual and team responses, weekly reports) and case studies using grounded theory and context analysis [17, 18, 19]. A total of 1,870 lines of code were generated and examined by three individual researchers. Then the representative quotes in the data set were tagged to the protocol of the four pre-established contextual characteristics, outlined in section 3.2.

3.1 Weekly Online Survey

In this paper, the first three phases (Research, Analysis, Ideate) were analyzed. In the last two phases, Build and Communicate, students had already decided on their solutions, so their method selection is more predictable, and their context had narrowed. Therefore, the Build and Communicate were not included in the analysis.

We started our analysis by examining the weekly survey responses from the six student teams. Paragraph-by-paragraph coding analysis was used to explore emerging themes and insights from the weekly survey results and teams' final deliverables. The following section (3.2) outlines the coding method.

3.2 Individual and Team Survey Analysis

The individual and team surveys were reviewed to identify relevant quotes based on the protocol below. Researchers tagged responses that highlighted students' perception of the definition of context and subsequently, the relationship between the method and context during method selection. Findings were organized by module. The tags were reflective of the definitions of proper method selection as presented previously (section 1.1) by Gericke and Chakrabarti.

These included an awareness for the following contextual characteristics:

- Listed sociotechnical interrelations (complex interaction between human behavior, technology, and complex infrastructures intrinsic to our society) (SI)
- Tying context to a specific industry domain (ID)
- Tying context to a specific user base (UB)
- Clear motivation and benefit of particular method (B)

To expand our scope, we included other comments that were particularly thoughtful or unique as part of our results.

3.3 Case Studies

At the end of the course, students were required to submit a case study based on a provided template. This template was modeled off *theDesignExchange* framework for case studies (Annex A). The teaching team read through all case studies and provided written feedback to the teams.

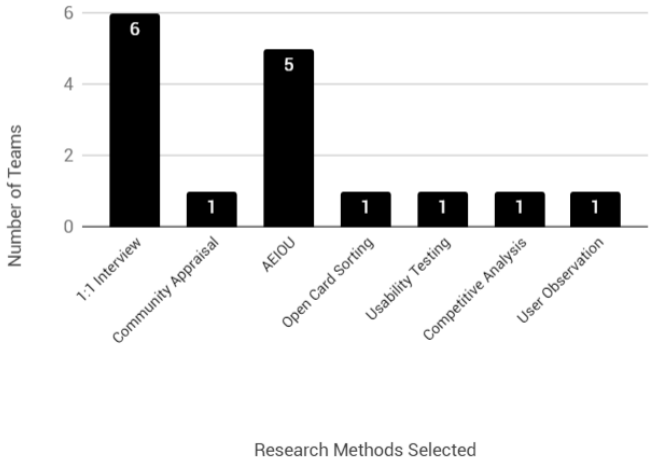
4. RESULTS/FINDINGS

4.1 Team Method Selection

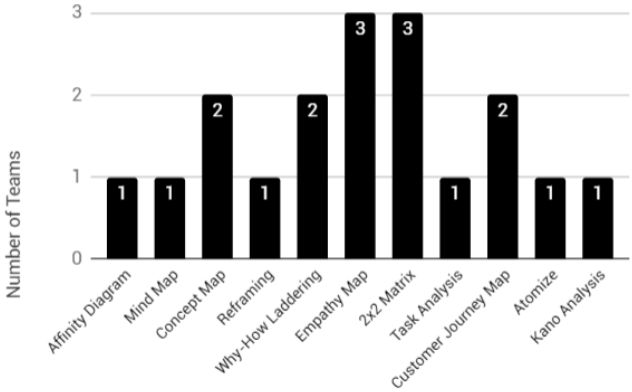
The top three methods from each team are shown in Figure 1. Team method selections were collected and visualized for the first three modules (Figure 1). The overall diversity of method selection for the Research and Analysis phases was lower than in Ideation. In the Research phase students chose to implement 50% of the overall set of methods introduced in class, and 69%, 71% in the Analysis and Ideation phase, respectively. Additionally, team-selected methods from all modules were collected and visualized (Annex C). Table 3 shows the methods that were not selected by the student teams for the Research, Analysis and Ideation modules.

Table 3 METHODS NOT SELECTED BY STUDENTS (FOR FIRST THREE MODULES)

Modules	Methods Not Selected
Module 1: Research	POEMS, POSTA, Closed Card Sorting, Focus Group, Conversation Café, Conjoint Analysis, Design Ethnography
Module 2: Analysis	Powers of 10, Spectrum Mapping, Context Mapping, Touchpoints Matrix, How Might We
Module 3: Ideate	Biomimicry, Do-Redo-Undo, Visual Brainstorming, 6-Up Sketches, Forced Analogy, Design the Box



Research Methods Selected



Analyze Methods Selected

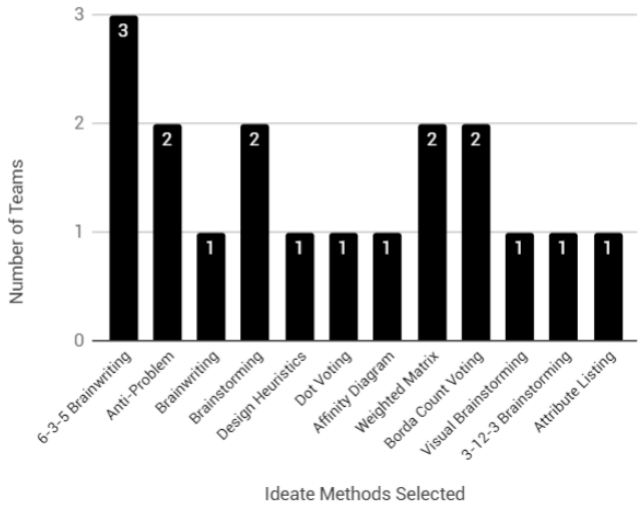


Figure 1. TOP THREE METHODS SELECTED BY TEAMS FOR FIRST THREE MODULES[1] (Top: Research; Middle: Analyze; Bottom: Ideate)

Comparing Team Method Selection to Method Popularity (tDX)

The top three selected methods from all six teams (in each module) were compared to the popularity (as measured by individual view counts) of all methods within that module (Research, Analysis, Ideate) on theDesignExchange (tDX). Individual view counts are the number of users who have clicked on a method on the website. The popularity could be considered a proxy for the prior probability that a method would be selected.

A correlational analysis was conducted, comparing the team method selection and the popularity of the method on tDX. The method selection data were normalized relative to the number of teams (six) and the popularity data were normalized relative to the method with the most view counts (Figure 2). For example, if all six teams selected one method, the x-axis scale would be 1, as seen in the Research Module.

The Pearson correlation coefficient was calculated to measure the relationship between the two variables. For the Research module, there was a strong relationship (0.62) with popularity, which can largely be attributed to the AEIOU method, which was used by nearly every team and was most popular in the data set. When calculating the Pearson correlation without AEIOU, the overall relationship is weak (0.37). This finding is not surprising given the general popularity of this method in the design process. In the Analysis and Ideate Module, the correlational coefficient was 0.41 and 0.38 respectively. Both values indicate a weak relationship. This finding is interesting because it illustrates that students were less focused on the popularity of the method and instead on its specific use in their project.

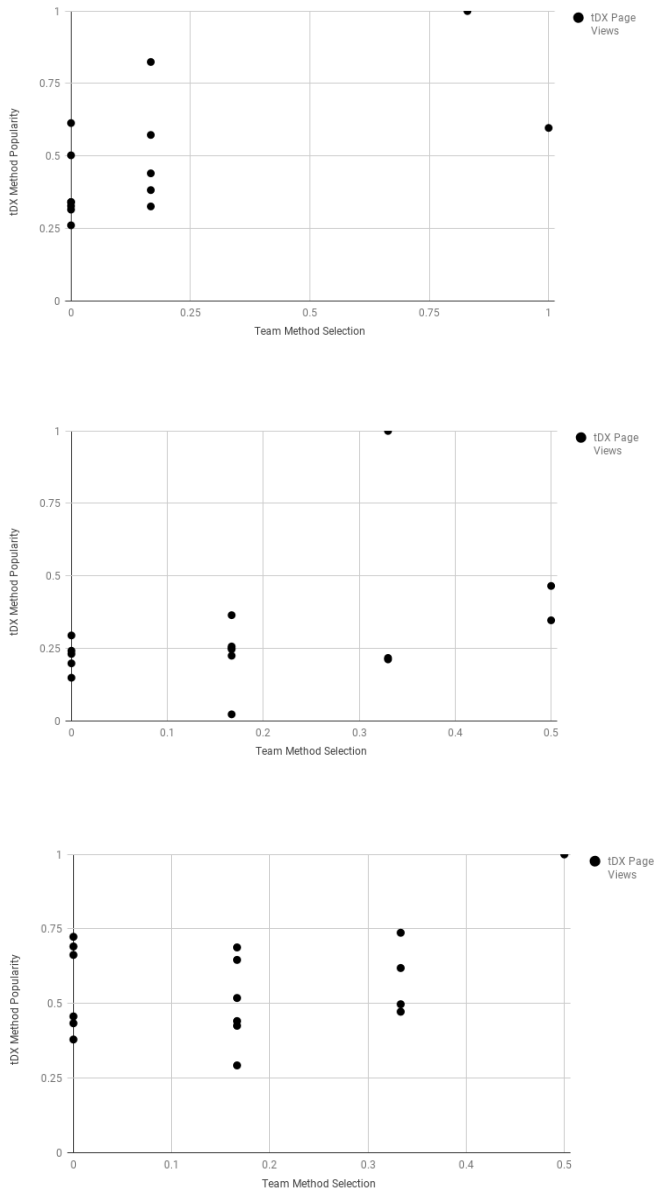


Figure 2. CORRELATION BETWEEN METHOD POPULARITY ON TDX AND ACTUAL TEAM SELECTION (Top: Research; Middle: Analyze; Bottom: Ideate). NOTE: THE METHOD LABELS WERE EXCLUDED TO KEEP THE DATA VISUALIZATION CLEAN

4.2 Why and How? - Teams

Individual and Team Survey Analysis (Research, Analysis)

[1] Dot Voting and Affinity Diagramming were methods selected by student teams but were not originally introduced during the Ideation module.

The diversity of method selection suggested that there were differences in the way students and teams approached the design problem throughout each module. Upon further investigation through qualitative analysis, both individuals and teams highlighted context-aware mindsets when justifying their method selection. The quotes below were extracted from student responses (both individual and team). The findings support the first two research questions, which investigate what contextual clues students consider and which contextual clues were mentioned.

Research

Throughout the Research phase, students attempted to strongly align their methods with the particular problem space they were working within. Given the original design challenge was about mobile sensing, it is not surprising that students focused on the "sociotechnical interactions" as well as well as their specific user group:

> *"I chose this method [POSTA] because it enables the researcher to identify new opportunities in the market, which is an aspect of this* ***design challenge****. I feel that the parameters of this method, People, Objects, Situations, Time, and Activity,* ***are all highly relevant to mobile sensing and will enable*** *the researcher to best collect information about how people interact with their devices."* (SI, ID)

> *"I think that a Focus Group would be a good way to gauge what* ***people's perceptions of the risks associated with generating sensitive data are****. With this method, people are more likely to reveal their true thoughts and opening a discussion this way will likely get* ***people to think about sharing sensitive information in ways that they hadn't before.****"* (SI)

> *"I think this method [Conjoint Analysis] would be a good way to optimize the features of our product.* ***Given that this is a design challenge involving human-mobile sensing robots****, I would imagine there would be many different attributes to our product that we would want to weigh against each other."* (SI)

> *"As we're trying to get* ***information on BART riders****, what better way than to go into the station and observe?* ***We will be able to see, in context****, what riders do and indirect observation will ensure that we're not influencing our customer's actions in any way." [User Observation]* (ID, UB, B)

Analysis

In the Analysis phase, students attempted to strongly align their methods with the particular problem space they were working within. Additionally, during the Analysis phase, there was more awareness for the user group based on the findings from the Research phase:

> *"Since we largely* ***chose to focus on younger adults and college students, I feel an empathy map is not as valuable as our target demographic is already one which we greatly relate to.*** *However, if we were working with a less familiar demographic, this would be invaluable for understanding their perhaps differing motives and perspectives."* (UB, B)

> ***"Our environment and customer population (BART commuters) is very diverse*** *and each person goes through some kind of process when it comes to commuting. This will* ***help us visualize the journey of each type of customer*** *and how they each approach a certain process." [Customer Journey Mapping]* (UB, B)

> *"From our research, we concluded that our potential users had* ***extremely divergent needs when it came to transitioning from Berkeley****. The concept map framework allows for many different nodes to be displayed and examined at once, and is* ***therefore perfect for the nature of the data that our team collected.****"* (UB, B)

> *"After having finished the research, we tried to find the* ***methods that best made sense to us and also would best complement the type of data we had acquired****. We knew that* ***campus safety was a very saturated topic and wanted to ensure we found new and unique ways to approach the issue*** *and thus chose reframing to try to find fresh solutions." (B, ID)*

Ideate

In the Ideation phase, students' (both individually and teams) were less focused on how the methods related to the industry sector and user group, but still cited some contextual clues as a basis for their selection:

> *"Solving the anti problem may be great as we are trying to solve* ***lack of connectivity and socialization****. Reversing that may help us to imagine what* ***our users life is like*** *if there is too much socializing and not enough alone time." [Anti-Problem]* (B, UB)

> *"I chose brainwriting as an alternative to brainstorming because* ***I think my group's quieter members will get a chance to have their voices heard and participate*** *if they are not under the same kind of pressure as a traditional brainstorming situation.* (B)

Overall, students exhibited awareness for how the design challenge, specific user groups, sociotechnical interactions, and team dynamics related to their method choice. During the ideation phase, there was less focus on the sociotechnical interrelations (SI) and tying context to a specific user base (UB) and more focus on the benefit of the method for their particular team. This is not particularly surprising as the goal of ideation is

to generate many concepts, before narrowing down the scope. Quantitative analysis presented in section 4.1 showed that overall diversity of method selection for the Research and Analysis phases was lower than in Ideation. As students are more mindful of their project context during Analysis and increasingly aware of their team needs in Ideation, they tend to choose a more diverse set of methods in order to better fit their specific needs. Providing students with a broader set of methods for each phase of the design process can lead to more diverse and thoughtful method selection. *TheDesignExchange,* which is a free, open-sources resources, can serve as a textbook to support these student mindsets.

5. CONCLUSION

Diversity of method sets enables more thoughtful consideration of appropriate method utilization based on specific user groups and industry sectors. Despite a small sample size, these findings shed light on students' mindsets during the method selection process. Particularly in the Research and Analysis phase, students often aligned their method choice with the design challenge, industry sector and user type, as evidenced by their survey responses. The weak relationship with popularity in the Analysis and Ideation modules indicates that students did not refer to method popularity as a metric for method selection. Educators can use this framework of diverse method sets in their classes to support a more contextually aware method selection process.

Each student team had vastly different project scopes and topics (Table 2), target user groups, and final deliverables. By using *TheDesignExchange* as a learning tool, students had more freedom to choose methods they felt were appropriate to their projects. As evidenced by student case studies, teams were able to both identify which method to use based on context and indicate findings. *TheDesignExchange* web portal can thus support a diversity of design projects, engaging students and educators alike.

6. FUTURE RESEARCH

Deeply understanding the mindset during method selection can inform the content layout of *theDesignExchange*. Today, methods can only be categorized by design phase (Research, Analysis, Ideate, Build). Exploratory research, including Think Aloud studies and instructor interviews, has indicated that this layout can feel "overwhelming" for method selection. Due to the collaborative and dynamic nature of the site, there is an opportunity for the portal to better capture the exact needs of students and practitioners alike during method selection.

TheDesignExchange will continue to serve as a teaching tool for human-centered design in the classroom. Selected case studies will be uploaded onto *theDesignExchange*. This summer, another Design Thinking course will be taught with this same method selection structure and will be examined.

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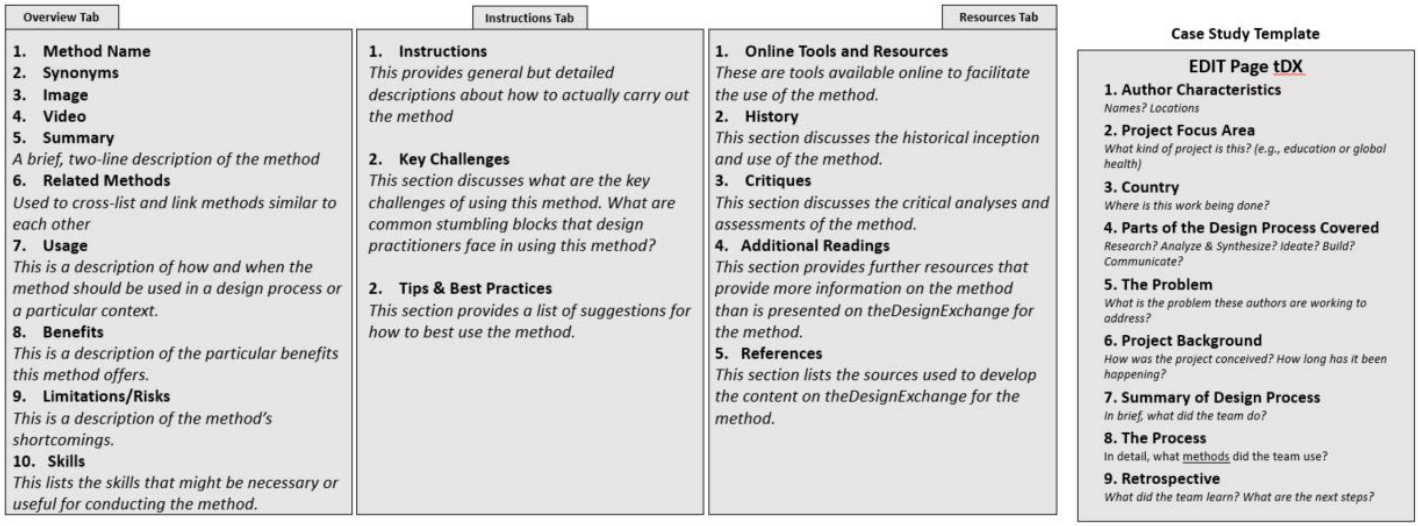
ANNEX A

THEDESIGNEXCHANGE METHOD AND CASE STUDY CONTENT FRAMEWORK



ANNEX B

ONLINE SURVEY PROMPTS (WEEKLY)

Weekly Surveys	Example Survey descriptions
Individual	Complete an individual method selection survey on Module 4: Build. Read descriptions on all methods assigned in module 4 (build). Then, select 3 design methods you would like to use in your team project. Describe why did you choose certain methods over others and why not.
Team Survey	Complete a survey on Module 4: Build. Select 3 design methods your team decided to use in your team project. Describe why did your team choose certain methods over others and why not. Students were asked to answer the following questions for each method (of three) selected: 1. How did your team agree on this method selection? (i.e. What was your team's decision-making process?) 2. What factors did you consider in choosing this method and why do you think it is an appropriate method for tackling the design challenge? 3. Upon completing the method selection survey, students were prompted to answer the following question: If your team was considering other methods, what made your team decide not to choose them? Please make sure to include the method names.
Team Weekly Report	Submit your weekly report including results of your works with 3 selected design methods in word format. This weekly report write-up is meant to be a reflection piece where your team can review how the project has progressed as a group and impacted your design outcomes within each of the 5 modules. Teams should justify why and how they decided to select particular methods and describe the results and outcomes from using each method. Include all meaningful insights and comprehensively discuss learnings and next steps. Please include documentation (pictures, interview transcripts, sketches, diagrams, frameworks, and etc.)

ANNEX C

VISUALIZATION OF TOP THREE METHODS SELECTED BY TEAMS FOR ALL FIVE MODULES: RESEARCH, ANALYSIS, IDEATE, BUILD, AND COMMUNICATE