Design Practitioners' Perspectives on Methods for Ideation and Prototyping

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Abstract

TheDesignExchange is a site dedicated to the support and development of the design thinking community. Its mission is to provide an online space for design thinking practitioners to share, discuss, and explore design thinking, allowing both novices and practitioners to expand and hone their expertise. Though there are many introductory experiences and courses available in design thinking, it is often difficult to find resources and support for advancing to the next stage of professional development, an aspect of which is being able to intelligently choose between the myriad of methods available, rather than relying on the subset of methods learned in school. *TheDesignExchange* aims to fill that void by organizing the available design thinking methods, developing a community of design educators and practitioners to evaluate those methods, and helping educate the next generation of design innovators. This

paper focuses on insights gained from two practitioner workshops associated with ideation and prototyping methods and describes the results of pilot testing with product design students in an upper division multidisciplinary course at UC Berkeley.

Keywords: design thinking, design methodology, ideation, prototyping

1. Introduction

Many reports emphasize the increasingly multidisciplinary nature of engineers' work, and the need for universities to train young engineers to work effectively with other disciplines. Design thinking is an inherently multidisciplinary process used by engineers, designers, architects, business people, and educators [1, 2, 3, 4], but these disciplines have each developed different approaches based on their own mindsets, skillsets and toolsets. Human-centered design methods, applied in the early stages of the product or solution development process, include developing insights through deep empathy for customers, the integration of divergent and convergent thinking, and rapid iteration around alternative concepts and prototypes [2, 3, 5, 6]. Finding the right design tool or method for any particular problem can be challenging, especially when presented with options from multiple disciplines. *TheDesignExchange* provides a structure and cross-disciplinary ontology that highlights successful design methods in use today, their variations, and examples of their use [7, 8, 9, 10, 11, 12]. It thus provides educators and practitioners alike with a versatile library of proven tools applicable to a range of disciplines. By promoting a community-of-practice model focused on an interest in the application of design processes/methods, *theDesignExchange* supports the cross-pollination of methodologies among the diverse range of contributors engaged in design.

To support educators and practitioners in exploring and expanding their design thinking expertise, *theDesignExchange* has collected a library of over 300 design thinking methods from the many disciplines in the design thinking space, including methods commonly used by engineers, designers, architects, business people and educators. To organize these methods and facilitate talking about methods and design thinking practice in general, we have begun development of an ontology of design methods [13]. Drawing on previous work done in design theory, communities of practice, and expert/lead user-generated content, it was determined that input from the design thinking community of practice should be included in both the ontology and site development. This input was gathered to (1) evolve the ontology structure and terms, (2) frame the features for *theDesignExchange* portal, and (3) build a sense of ownership over the portal within the community of practice to help encourage its adoption as a community resource. This paper focuses on the insights gained through two of a series of five workshops with design practitioners held to gather this input: one workshop focused on *Ideate* methods and one workshop focused on *Build* (i.e., prototyping) methods. To demonstrate use of *theDesignExchang*e on advanced undergraduate product design students, pilot exercises conducted in an upper division multidisciplinary course at UC Berkeley are summarized.

2. Background

The methods in *theDesignExchange* were collected through a literature review, drawing on academic publications (e.g., [14, 15],) online collections (e.g., [16, 17],) books (e.g., [4, 10]), and industry toolkits (e.g., [18, 19]). Identical methods between sources were combined, noting the multiple names used for the method. Similar but not identical methods were grouped as *variations* – for example, a *mobile diary study* is listed as a variation of a *diary study*.

Four initial workshops were then conducted in 2011 and 2012 focusing on understanding the needs of the community, which helped to direct the development of a prototype of *theDesignExchange*. In this prototype, by matching method definitions with method group descriptions, the methods were organized into five preliminary groups associated with the design process: *Research*, *Analyze*, *Ideate*, *Build*, and *Communicate*. Within each of those groups, methods were further categorized by a set of categorization schemes. These categorization schemes were based partially on previous work collected during the literature review, and partially on differentiating characteristics between methods. In this paper we focus on those workshops associated with ideation (called "ideate" methods in *theDesignExchange*) and prototyping (called "build" methods in *theDesignExchange*). *Ideate* methods focus on creating new ideas for products, services, experiences or business models. In addition to brainstorming and brainwriting methods, methods and categorizations schemes include those from gamestorming [20] and co-design.

Build methods allow designers to move from concepts to physical or visual realization. The categories of this group pull from a number of sources and build off of work described by Bjoern Hartmann [21], who reviewed prototyping methods in particular. The scope of *Build* methods include horizontal slices, vertical slices, and the full scope. A horizontal slice explores a breadth of functionality, such as with a customer journey map. A vertical slice explores one functional aspect of the design in depth, such as a mechanism mock-up [7]. A more thorough discussion of the overall method ontology can be found in [13]. Roschuni, et al, [22] highlight insights from the workshops on *Research*, *Analyze,* and *Communicate* methods.

3. Methodology

3.1. *theDesignExchange* in Design Practice

In order to evaluate the authenticity of its methods and the approaches used in tackling design problems in industry, *theDesignExchange* hosted a series of workshops with design practitioners from the San Francisco Bay Area in California, between July and November 2014. Workshops ranged in size from 20-35 participants, with disciplines ranging from marketing to UX design to engineering design.

In this paper, we focus on two of these workshops: one focused on *Ideate* and the other on *Build* methods. Workshop participants were recruited through a mailing list of professional design and user researchers in the local geographic area. Workshops were hosted at a variety of design and user research firms in San Francisco, but followed a common format: (1) networking and refreshments, (2) short presentation, (3) hands-on

activities, and (4) sharing and discussion. The hands-on portion of each workshop was chosen to engage participants in a meaningful design activity that could then be used to inform *theDesignExchange*. Though *theDesignExchange* team developed these activities, a member of the host company worked with the team to conduct each workshop. Members of *theDesignExchange* team took notes and photographs to document the workshop activities and outputs, during both the small group discussions and the large group share-outs. All of the documents, drawings, and clusters created were also collected for later analysis. A description of the activities for the *Ideate* and *Build* workshops is given below in Sections 4 and 5, respectively.

3.2. *theDesignExchange* Supplementing the Classroom

The educational benefits of *theDesignExchange* were further examined in an educational context with advanced product design students in an upper division, multidisciplinary course taught at UC Berkeley with 82 students (28 female, 54 male) from various fields of engineering, as well as computer science, architecture, business, humanities and social sciences. Many of these students had taken prior introductory design courses in their own major or through the student-led {design.} course run by Berkeley Innovation [23]. This course covers the design process and conceptual design of products, services, experiences, software, and business models. In this project-based learning course a student's design ability is developed in a design project or feasibility study chosen to emphasize innovation and ingenuity, and provide wide coverage of engineering and business topics, with an emphasis, this semester, on entrepreneurship opportunities. Social, environmental, economic, and political implications are included. There is also an emphasis on hands-on creative components, teamwork, and effective communication. Near the start of the semester, students were also asked to complete an online creativity test to measure their self-assessments of creative confidence and attributes [24, 25]. During the second half of the semester, the students were given the test again, with the order of the questions rearranged. The creativity assessment presented statements on problem solving and ways of working and asked students to assess themselves as "not at all", "rarely", "sometimes", "often" and "very often" for each statement. For each question, a student could get between 1 and 5 points based on their assessment with a higher score indicating a higher level of creativity for that statement with a total possible score of 80 across 16 statements.

This semester, several ideation methods (brainstorming, attribute listing [morphological matrix], metaphorical/analogical reasoning) featured on *theDesignExchange* were presented to students during class. As a part of the course, students were asked to complete a concept generation exercise, including a description of their concept, a sketch, a list of features and attributes. They were also asked to list specific creativity methods, if any, that they used during the exercise. Each student was tasked with generating 10 concepts individually before expanding them with team exercises. Students were encouraged to browse the "ideate" section of *theDesignExchange* to find ideation methods to use for this exercise. The students were asked to use a concept half-sheet form. The goal was to see which methods were most popular and whether there were methods used not in *theDesignExchange*.

Students were also given the option of completing an *Ideation and Early Prototyping Module* to help them become familiar with a range of design methods and with

theDesignExchange as a tool for finding new methods. The module asked students to learn about three specific ideation methods listed on *theDesignExchange*: Attribute Listing; Do, Redo, Undo; and Forced Analogy as well as three methods for prototyping: Paper Prototyping; Activity Modeling; and Experience Prototyping. These methods were selected because they outlined a spectrum of strategies rather than focus on a single specific strategy. Students were asked to explore the range of other ideation methods at *theDesignExchange* and explain which they found most interesting and why. They were then asked to respond to five open-ended questions that involved applying the methods to simple design examples. An accompanying rubric was developed to assess the quality of responses to the module. If a student's response were assessed as satisfactory, a student would become eligible to receive a badge (the Ideation and Early Prototyping badge) from *theDesignExchange t*o indicate that they had some level of familiarity with a range of ideation methods. Pilot testing suggested that the module would take about an hour to complete. As an incentive to complete the module, students were told that one submission would be chosen at random and be awarded $100.

4. Ideate Workshop

During the *Ideation Workshop*, held at DesignMap, participants were given an introduction to *theDesignExchange*, and then tasked to spend 30 minutes in groups of 4-6 designing the user experience for the search function of the site (the design task is shown in Figure 1). To do so, they were provided with a list of roughly 40 ideation methods that can be found on *theDesignExchange* to use as they addressed the design task.

Design Task

- Come up with a solution to make finding methods on *theDesignExchange* easy and intuitive. Consider novel UIs (we can always scale back later).

Design Principles

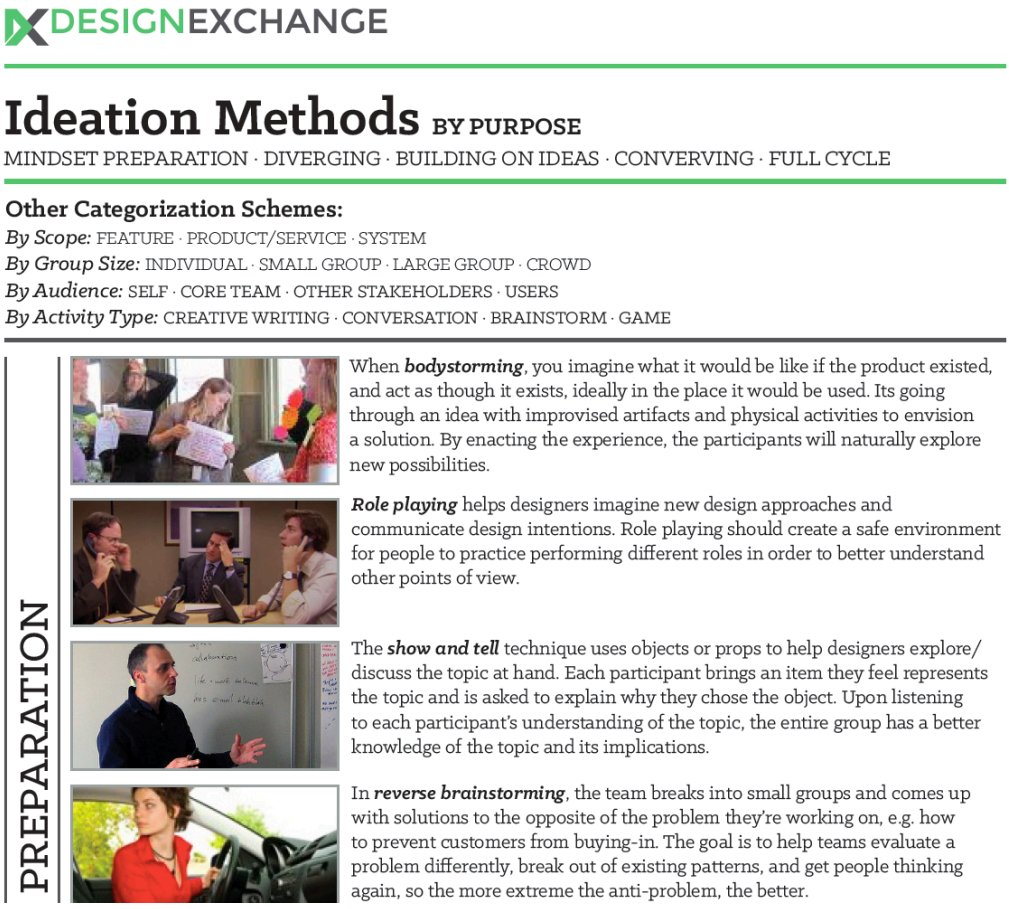
- Make it easy for novices and experts (you!) to find the methods they're looking for, even if they don't know exactly what they are looking for.
- Let users pause and come back: when a user leaves the site and comes back, they should be able to easily pick it up where they left off.
- Allow users to build a reputation or expertise and network with each other.
- Empower users to create a community and a shared body of work.
- Allow users to efficiently manage their time spent on design activities.
- Create a fun and energetic environment that users enjoy participating in.

Figure 1: Design task given to participants during ideation workshop.

We used a design approach developed by our collaborators at DesignMap called a "design swarm" in which a group of 10-15 designers or other skilled brainstormers get together to focus on a new, challenging problem. After an hour they get back together

and present their ideas as photos of their whiteboards. DesignMap recommends this a great method for jumpstarting a project [26].

To address the design task, the five groups were each given the freedom to pick their preferred ideation method, employing methods from a reference sheet of methods in *theDesignExchange* (Figure 2), if desired.



DESIGNEXCHANGE

Ideation Methods BY PURPOSE

MINDSET PREPARATION · DIVERGING · BUILDING ON IDEAS · CONVERVING · FULL CYCLE

Other Categorization Schemes:

By Scope: FEATURE · PRODUCT/SERVICE · SYSTEM

By Group Size: INDIVIDUAL · SMALL GROUP · LARGE GROUP · CROWD

By Audience: SELF · CORE TEAM · OTHER STAKEHOLDERS · USERS

By Activity Type: CREATIVE WRITING · CONVERSATION · BRAINSTORM · GAME

PREPARATION

When ***bodystorming***, you imagine what it would be like if the product existed, and act as though it exists, ideally in the place it would be used. Its going through an idea with improvised artifacts and physical activities to envision a solution. By enacting the experience, the participants will naturally explore new possibilities.

Role playing helps designers imagine new design approaches and communicate design intentions. Role playing should create a safe environment for people to practice performing different roles in order to better understand other points of view.

The ***show and tell*** technique uses objects or props to help designers explore/ discuss the topic at hand. Each participant brings an item they feel represents the topic and is asked to explain why they chose the object. Upon listening to each participant's understanding of the topic, the entire group has a better knowledge of the topic and its implications.

In ***reverse brainstorming***, the team breaks into small groups and comes up with solutions to the opposite of the problem they're working on, e.g. how to prevent customers from buying-in. The goal is to help teams evaluate a problem differently, break out of existing patterns, and get people thinking again, so the more extreme the anti-problem, the better.

Figure 2: Image from the sheet given to participants during Ideate workshop.

Figure 3 shows a group of designers working on their ideation task.

- Group A began with a "post-it session" to get biases and ideas from each member, and then worked collaboratively to develop a single concept to present during the "share-out."
- Group B used a method called "6 Up Sketches" where each group member generated a rough sketch for six unique concepts, leading to a large number of concepts.

- Group C started by thinking out loud to define and elaborate on three general ideas.
- Group D used a method called "Reverse Brainstorming," or "The Anti-Problem" which asks participants to generate solutions for the opposite of the problem they are working on (i.e., how to prevent site users from discovering new methods). This group uniquely chose this method at random from the reference sheet of methods.
- Group E worked collaboratively from the start to define and articulate the details of one idea.

Figure 3: Participants ideating during Ideate workshop.

The workshop highlighted a few of the many ways practitioners approach idea generation. One participant remarked that they often choose methods based on what "sounds fun" or interesting at the moment. Some groups took time to choose a formal method while others jumped right in without an apparent ideation plan. Even expert designers commented that *theDesignExchange* exercise exposed them to new methods that they would add to their toolbox. Based on feedback during the discussion phase of the workshop, we revised the initial categorization scheme for classifying *Ideate* methods. This scheme is shown in Table 1.

Table 1: Categorization Scheme for Ideate Methods.

Theme	**Category**	**Description**
Activity type	Talking	These methods stimulate conversations between group members, and are therefore methods for indirect ideation
	Drawing	These methods use drawing to result in creation of ideas
	Deciding	These methods help to down-select and choose ideas
	Writing	These methods use creative writing techniques to indirectly develop ideas

	Building	These methods use building (prototyping) to result in creation of ideas
Purpose	Prepare mindset	These icebreaker type of methods prepare participants for ideation
	Diverge	These methods allow participants to freely diverge and generate new ideas
	Build on ideas	These methods allow participants to build and elaborate on previously created ideas
	Converge	These methods allow participants to assess (i.e. for desirability, viability, feasibility) and prioritize ideas
	Full cycle	These methods can be used during the full design process cycle
Desired scope of impact	System level	These methods are most useful for coming up with new business models, product-ecosystems, etc.
	Product level	These methods are most useful for coming up with new products or services
	Feature level	These methods are most useful for coming up with new features of a particular product or service
Participants	Individual	These methods allow a solo participant to ideate
	Core team	These methods allow a core team of designers and design researchers to ideate together
	Relevant stakeholders	These methods allow members of the company or organization (but outside of the design or research team) to ideate
	Users (co-design)	These methods allow members of potential customer and/or user groups to ideate
Group size	Individual	These methods are meant for an individual participant
	Small	These methods are meant for a group of 2 to 8 participants
	Medium	These methods are meant for a group of 8 to 25 participants
	Large	These methods are meant for a group of 25 to 50 participants
	The crowd	These methods are meant for a group of more than 50 participants
Complexity	Simple	These methods require 2-3 steps
	Average	These methods require 4-8 steps
	Complex	These methods require more than 9 steps
Time	Quick meeting	These methods are suitable for a meeting of 30 minutes or less
	Normal meeting	These methods are suitable for a meeting of 1 to 2 hours
	Half day	These methods are suitable for a meeting of about 4 hours
	Full day	These methods are suitable for a meeting of about 8 hours
	Multi-day	These methods are suitable for several sessions taking place over multiple days
	On-going	These methods require continuous collection and are often less structured

5. Build Workshop

During the *Build* Workshop, held at Autodesk's new prototyping facility, Pier 9, participants were first given a short presentation on methods of prototyping and

building. They were then split into groups of 4-6 and each given a set of roughly 35 prototyping method cards from *theDesignExchange*, complete with a method title and a brief description (Figure 4).

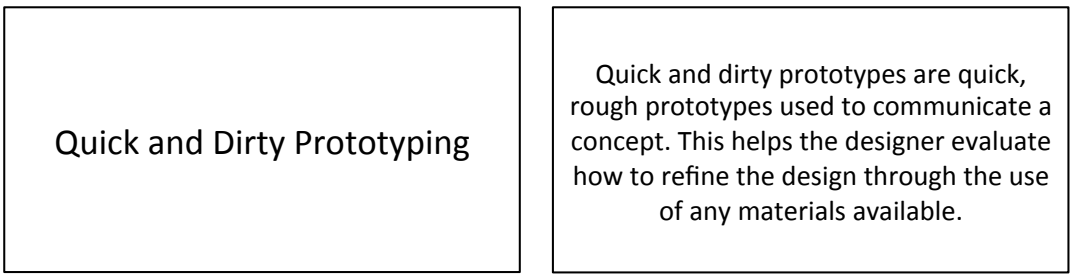


Figure 4: Example of a method card given to participants during Build workshop.

They were then asked to conduct an open card sort, taking the method cards and sorting them into categories of their choosing (Figure 5). This activity led to a wide range of categorizations and highlighted the many different ways that practitioners think about building methods across disciplines.

Figure 5: Participants card sorting during Build workshop.

In the discussion that followed, participants in the *Build Workshop* highlighted usability issues with the methods and their descriptors. For example, participants stated that the methods were harder to recognize by name than by description. This led to a conversation on the utility of "aka"s and related methods, to make them more easily recognizable by designers with different backgrounds. Participants also suggested providing representative pictures of each method along with examples of the method in use on *theDesignExchange*.

To present the methods in *theDesignExchange*, workshop participants suggested arranging methods in the order in which they would be used in a design process. They also proposed the use of spectrums on which to orient the methods (e.g., virtual to physical), but noted limitations with this approach.

Participants posed questions to help categorize methods: for what kind of audience is the designer building? What resources are available? What is the skills set of the designer? These questions all pose areas for further research and are noted to be very important as a designer or design researcher chooses an appropriate building method.

Finally, participants spoke of a recommendation system interface that would be helpful in choosing and discovering methods. They brought up Spotify and Netflix as examples of systems that offer similar methods; a similar interface would be useful in *theDesignExchange*.

Following the workshop, we developed a categorization scheme for classifying *Build* methods. This scheme is shown in Table 2.

Table 2: Categorization Scheme for Build Methods.

Theme	Category	Description
Stage of process	Mock-up	These methods produce prototypes that are not fully functional
	Operational	These methods produce a prototype that have the look and functionality of the final design
	Production	These methods produce a prototype that are ready to be produced
Fidelity	High	These methods produce a realistic prototype with the look and function of the final design
	Medium	These methods produce a semi-complete prototype of the final design
	Low	These methods produce a prototype that is easy to create, inexpensive to change, and good for providing a basic mockup
Offering format	Digital offering	These methods produce a digital prototype
	Physical offering	These methods produce a physical prototype
	Either	These methods can be used to produce a digital or physical prototype
Product or service	Product	These methods are useful to prototype a product
	Service	These methods are useful to prototype a service
	Either	These methods are useful to prototype either a product or service
Format	Abstract	These methods produce a prototype that enhances the designer's understanding of what it might be like to use the product or service
	Virtual	These methods produce a prototype using a digital medium
	Tangible	These methods produce a prototype using a tangible medium
Aspect	Role/context	These methods produce a prototype that explores the product's role in the larger use context
	Appearance	These methods produce a prototype that explores the product's visual appearance

	Implementation	These methods produce a prototype that explores the technical implementation of the product's function
	Behavior	These methods produce a prototype that explores product's behavior and response
Scope	Vertical slice	These methods produce a prototype that explores one aspect of the design in depth
	Horizontal slice	These methods produce a prototype that explores one entire level of the design with limited depth
	Full scope	These methods produce a prototype that explores the full scope of the design
Purpose	Experiment	These methods are used to compare and narrow options
	Validate	These methods are used to test whether implementation works as expected
	Explore	These methods are used to generate more options
	Persuade	These methods are used to convince a client of the feasibility of a project before starting major work on it
	Demonstrate	These methods are used to provide concrete examples to help anchor a discussion about the design

6. Pilot Testing on Advanced Design Students

6.1. Half-Sheet Concept Generation Results

The half-sheet concept generation exercise was initiated as an individual homework assignment, which was then used to expand concepts during an in-class team exercise. After browsing the "ideate" section of *theDesignExchange* to find ideation methods to use, they were asked to list specific creativity methods, if any, that they used during the exercise. An example individual contribution is shown below in Figure 6.

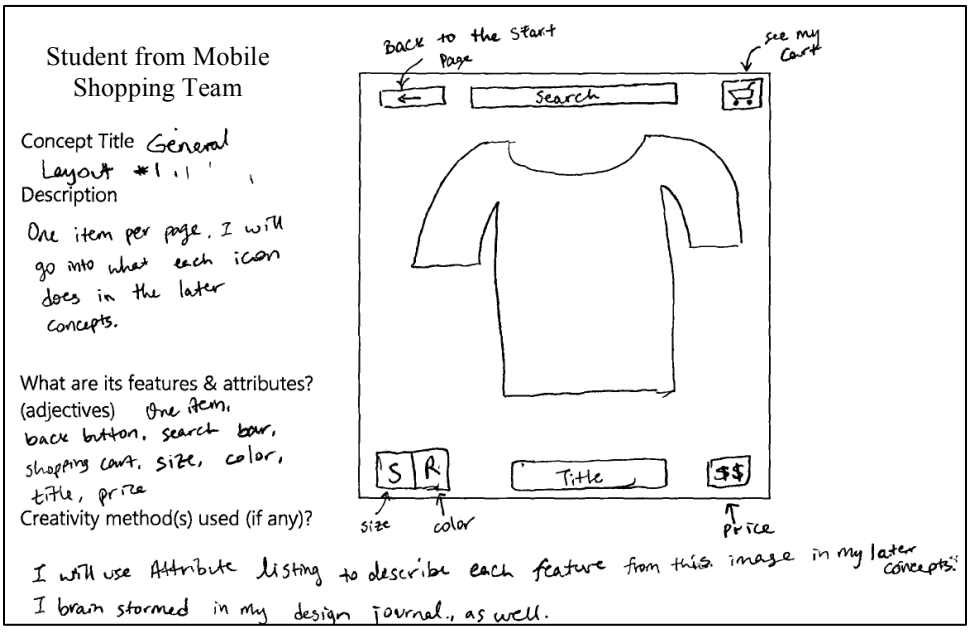


Figure 6. Sample concept generation half-sheet with annotation for method used.

Out of the 36 methods collectively listed by students in the concept generation exercise, 11 methods were ones that were featured in *theDesignExchange*. A summary of the methods used that are from *theDesignExchange* are in Figure 7.

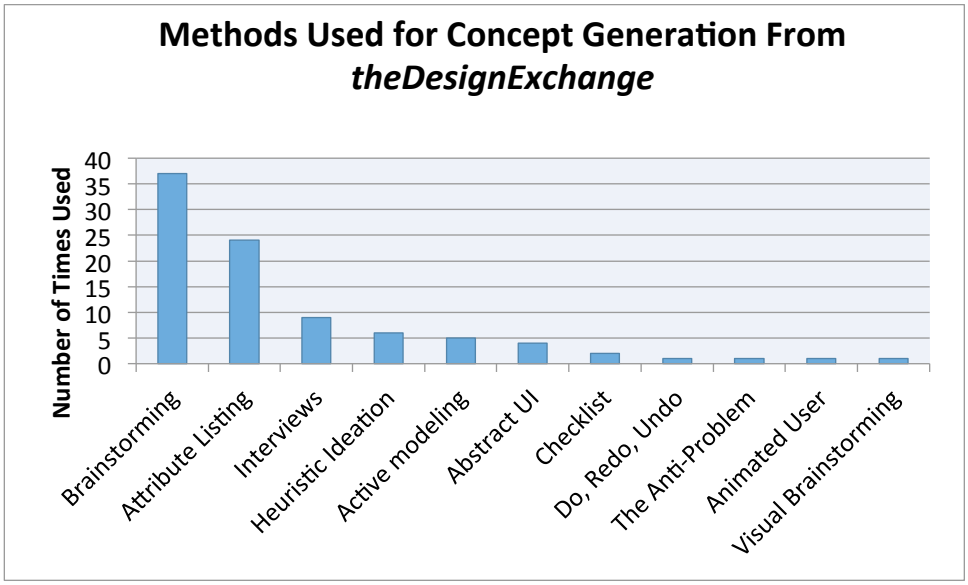


Figure 7: Methods used for the half-sheet concept generation exercise that are in *theDesignExchange*

In addition to the 11 methods from *theDesignExchange,* students listed nine methods that were related, but used alternate names, to methods featured in *theDesignExchange,* suggesting that synonyms should be included to assist browse and search features. Two methods related to TRIZ (e.g., "evolution") were not included, but will be added in future. Fourteen methods listed were generic (e.g. "divergent thinking", "concept generation", "problem solving") or unknown to the authors (the authors are following up with the students for those in the latter category). Figure 8 shows the frequency with which students mentioned these methods that were not listed on *theDesignExchange*. Only methods mentioned three times or more are included.

6.2. Creative Confidence

Midway through the semester, after theDesignExchange complemented in-class activities of early prototyping and testing, students were given the post-survey on creative confidence [27]. As a class overall, the students' self-assessments increased significantly from 49.4 points to 54.7 points on average between the pre- and the post-creativity test (student t-test with a p-value of 9.357E-12). An illustrative example of a specific question on the creativity assessment, students who selected "not at all" for the statement "I often ignore good ideas because I do not have the resources to implement them" earned 5 points while "very often" only earned 1 point. In the pretest, the average score for "I often ignore good ideas because I do not have the resources to

implement them" had an average score of 2.7 and the average in the post test increased significantly to 4.2 (student t-test with a p-value of 2.07E-25).

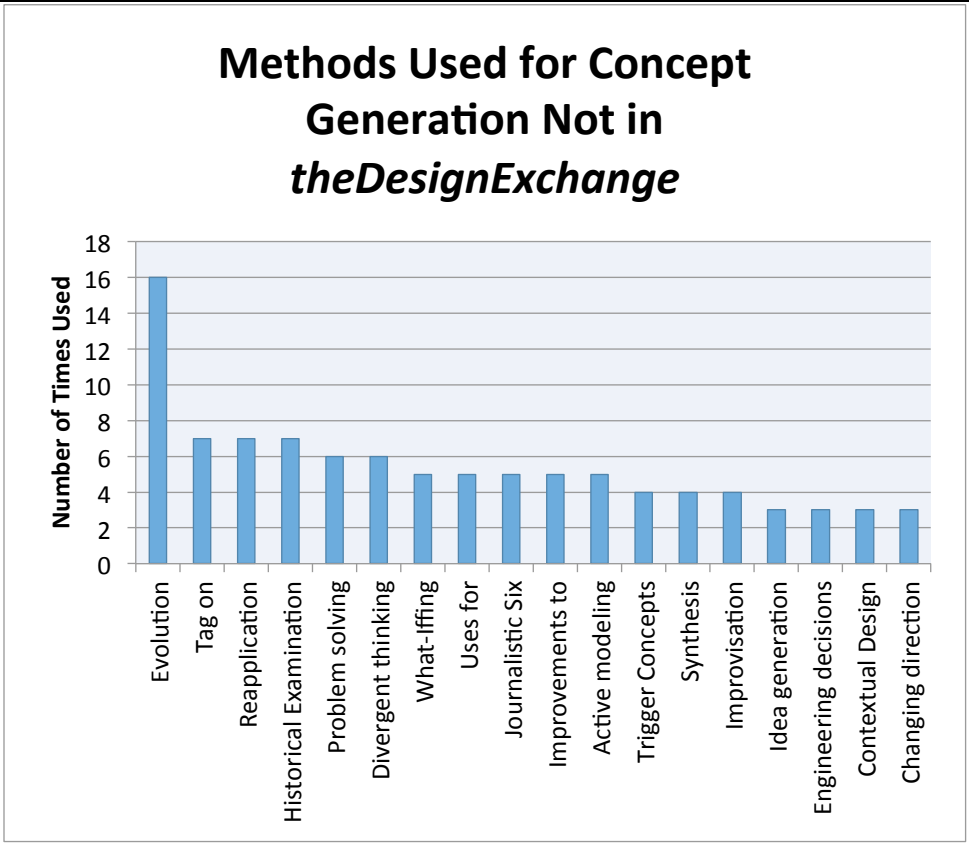


Figure 8: Methods used for the half-sheet concept generation exercise that are not in *theDesignExchange*

6.3. Ideation and Early Prototyping Module

Five students completed the ideation and early prototyping module. These were assessed against the rubric and all were found to be of sufficient detail and quality to be worthy of an Ideation and Early Prototyping Badge. They reported encountering an average of 7 new ideation methods on *theDesignExchange* that they had not known previously (min = 3, max = 13). A common theme was found across the completed modules with respect to the types of ideation methods students found interesting or might be valuable in the future, and how those methods might apply to their own projects. All five submissions referenced the value of various ideation methods as a tool for enabling design understanding beyond the individual designer. This broader external understanding could be among the student's project team, as noted by one student who said of brainwriting, "Since our team is prone to either the loudest people talking or the more task-conscious people, this way we can make sure everyone participates." This understanding could also extend to their project's larger market of users. A student said that brainwriting "seems like it would be an effective way to bridge the gap between different cultures as well," while another one states, "we've

been taking a very narrow approach to our project, without considering the impact our concepts can make on a global scale…. I think Forced Analogy would have taken us outside of the box, as well, since we kept thinking of daily items very literally." Similarly, the student discussed their thoughts on early prototyping methods, and the underlying theme here again was that of using methods to guide the team, not just an individual, to better outcomes by reaching connecting with users. In particular, the student noted that prototypes are valuable because they would "better allow our group to get a sense of what direction we are trying to pursue (such as the Create Frameworks method) and the second being the physical products we can have to engage potential customers..."

7. Conclusions and Future Work

This paper summarizes the findings of practitioner workshops on ideation and prototyping, including lists of the categories of methods identified, based on a qualitative analysis of the conversations that were held. Based on our insights from expert/novice differences, future work will be directed towards methods for which *theDesignExchange* could be used to achieve levels of proficiency in use of early stage design methods.

Implications for enhancing professional skills, industry practice and design education note that the typical design curricula face time constraints that limit the number of design methods that can be taught in any individual course. This leaves students and young practitioners with few methods in their toolbox. However, interactive repositories such as *theDesignExchange* present the opportunity to expose students to a far larger space of possible design methods and allow them to pursue learning about design tools beyond their formal classroom education. Results from classroom experiments complementing formal design education with online educational modules associated with *theDesignExchange* highlight the need to expand the number of methods included. Findings from the online educational modules further suggest that learning about new methods from *theDesignExchange* enables students to think beyond themselves, and consider how to engage in design with their own teams and within the larger communities that they are designing for.

8. Acknowledgements

The authors wish to thank our industry collaborators who hosted our workshop series: Autodesk, Frog, Goto Media, DesignMap, and IDEO and our team of faculty and students at UC Berkeley and MIT for their input and dedication to *theDesignExchange*. This work was partially supported by NSF CMMI-1334361.

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