

The Development of Design Thinking:
The Role of Personal and Pedagogical Factors

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April 6, 2012

Abstract

A wide range of design literature discusses the role of the studio and its related pedagogy in the development of design thinking. A number of potential factors that affect this development process are posed by scholars in a variety of design disciplines, but a full understanding of these factors as experienced from the student perspective is lacking. I examined the experience of first-year design students as they develop patterns of thinking, including a discussion of factors reported by the student. Factors identified in the literature were confirmed. Additional factors relating to group work, culture shock, critique, individual versus group identity, and the design influence of people and curriculum are identified and reported.

The Development of Design Thinking: The Role of Personal and Pedagogical Factors

Design as a recognized discipline and method of inquiry has increased in scope and breadth, and the focus of design pedagogy has shifted to recognize and adapt to digital methodologies and react to factors encountered in traditional design learning. Design pedagogy—and by indirect extension, the studio design approach—has a long history, spanning from the early methods utilized at the *École des Beaux-Arts* in the late 19th century (Kuhn, 2001) to the present day. While these traditional studio methods have adapted over time through the differentiation of design disciplines and pragmatic applications of technology (Findeli, 1990), the core blending of functional and structural elements in a problem solving orientation have been consistent across a wide variety of design disciplines (Kuhn, 2001; Brandt, et al., 2008). While a core design pedagogy has been widely implemented, the role of the pedagogy in moving a student toward mastery, linked to a change in the way they think about design (Siegel & Stolterman, 2008; Cross, 2011), is not well understood. In this study, I will evaluate the experiences of first-year design students to understand factors that affect their development of designerly thinking.

Definitions

Design disciplines in their normative pedagogical forms are generally seen as bound by the methodology and praxis of the design studio (Cross, 2007; Schön, 1983), which is comprised of an informal learning environment shaped by exploration and peer and instructor critique with little direct instruction. The design studio is also typically structured on the premise of design thinking, whereby individuals—all of whom have the innate potential for design ability (Cross, 2007)—learn to think and act in a context of design judgment and situational appropriateness to develop and defend solutions rather than using a predefined structure or linear process (Boling & Smith, 2010; Brandt, et al., 2008; Breslin & Buchanan, 2008; Teal, 2010; Shaffer, 2003). Design thinking, as originally proposed by Cross (1982) includes four important features: it is constructive in nature, it addresses ill-defined problems, it is solution-focused, and is dominated by problem solving.

Schön (1987) presents this design studio as a location where projects are individually or collaboratively executed, where projects are normally selected based on their applicability and conformance to the actual practice of that design discipline. The design studio and its intrinsically related design pedagogy are treated together in this review, with the design studio acting as the primary outlet of the generally accepted norms of an overarching design pedagogy, a feature that Shulman (2005) terms a “signature pedagogy.” Although design pedagogies exist that do not rely on the studio model as a primary driver, these approaches are not seen as normative within design education as a whole (Brandt, et al., 2008).

Review of Literature

A literature review was conducted to establish a baseline of design pedagogy and potential factors that affect the patterns of design thinking of the design student as they transition from novice to expert designer. The identified literature includes the application of this signature pedagogy in a variety of design disciplines, including: computer science, graphic design,

instructional design, architecture, and human-computer interaction. From the resulting identified literature, emergent candidate themes of factors that are informed by design pedagogy were identified. These emergent themes, developed and supported by related literature, form the tentative outline of potential factors that follows.

Environmental Factors

Private and public space. For many new studio programs, the lack of defined studio space is problematic, resulting in the lack of the desired studio culture, which this shared, persistent space denotes (Blevis, Rogers, Siegel, Hazlewood, & Stephano, 2004; Reimer & Douglas, 2003). It is suggested that a mix of public spaces and defined private work areas meets the needs of the design studio most succinctly, providing common areas for critique and peer interaction, while also allowing students to work in a consistent, self-defined space (Wang, 2010; Reimer & Douglas, 2003).

Contrast to traditional classroom space. Introductory design students on the graduate and undergraduate levels unfamiliar with the environment that the design studio denotes may be uncomfortable due to the lack of apparent structure or adherence to traditional classroom norms (Burdhardt & Hacker, 2004; Demirba & Demirkan, 2003; Ochsner, 2000). This contrast is especially problematic for graduate students entering a design discipline from a field outside the traditional design experience, for instance, students entering a graduate program in Human-Computer Interaction from an undergraduate background in Computer Science (Boling & Smith, 2010; Siegel & Stolterman, 2008).

Unfamiliar tools and norms. A design student uninitiated to the design studio is frustrated by the difference in tools with which to express themselves (Mawson, 2003; Ochsner, 2000). In place of notes and textbooks, a design studio is most frequently oriented towards sketching (Buxton, 2007; Do & Gross, 1996; Lee & Breitenberg, 2010) and rapid prototyping (Akalin & Sezal, 2009; Dutton, 1987), which may require a wide range of tools and media depending on the target environment or specific design profession. Any combination of these tools, which eventually allow for thoughts to be quickly captured for quick iteration (Lee & Breitenberg, 2010; Mawson, 2003), require mastery in isolation prior to being useful in the ideation process (Norman, 1998).

Complexity of technological tools. While the physical design studio introduces a large number of physical tools that may create feelings of unfamiliarity or lack of immediate comfort, the online or digital studio experience creates additional layers of required technological competence (Marx, 2000; Oxman, 2008; Gross & Do, 1999). Marx (2000) concludes that the technological competencies must be separated from the design-specific competencies to maximize the effectiveness of the studio experience, regarding tool-level competency as secondary.

Social Factors

Social issues within the design studio may appear at the introductory level, as a function of discomfort when working with peers or openly receiving feedback, or social issues might reactivate in developing or intermediate design students who have created mental structures or

design processes—some of which may be protective in nature (Ochsner, 2000) —that are self-limiting the designerly progression of that student. The core social activity of the studio, however, is the critique process—both in the giving and receiving of critique—which generally takes place in the context of design production (Blevis, 2010). Within the general work processes of the studio, the introduction of the group dynamic also often requires collaborative group work and a willingness to break rules in an organized sense to encourage innovation (Gregory, 2003; Wylant, 2008), which requires additional social interaction in an organized, consensus-oriented way.

Willingness to give critique. The design studio is founded upon a culture of open critique (Wang, 2010), both between peers and professors, encouraging reflection and learning (Pringle, 2009). Designers can construct their own design knowledge through the act of critique and self-reflection about the design processes of their colleagues (Lewis, 2005; Soufi & Edmonds, 1996). As a corollary to the process of accepting critique, questions asked during a formal or informal critique may add dimension to the creative process, spurring innovative thinking in all studio participants (Logan, 2008).

Willingness to receive critique. Designers must be willing to accept regular critique in the design studio environment, as an outgrowth of the experiential journey to becoming a practitioner (Pringle, 2009; Danvers, 2003). The designer can interact with the instructor to justify their actions—through a synthesis of verbal and visual components—of telling and showing (Demirba & Demirkan, 2003; Schön, 1983), or the critical process of evaluation can result in misconceptions about design principles (Oxman, 1999). In particular, Siegel and Stolterman (2008) note that an unwillingness to accept critique in a constructive way can result in a difficult transition between their stages of pre-emergent thinking and designerly thinking.

Formative Factors

Formative factors describe how an entry-level designer tends to think about the design discipline, or, in a meta-cognitive sense, how the student would describe or explain their relationship to or knowledge of design.

Personal design knowledge. The goal of the design studio is to produce students who “think” like someone in that design field (Cross, 2011). In the architectural studio, the goal is to produce a student that thinks like a practitioner in the specified design discipline (Ledewitz, 1985; Oxman, 1999). Mapping the progress of an individual student to this general norm, however, is less clearly defined, even to a successful design student or practitioner (Yilmaz, Seifert, & Gozalez, 2010). Ledewitz (1985) notes that, “despite the fact we do not define [design] precisely, we can easily distinguish those students who have learned to ‘think architecturally’ from those who have not” (p. 3). Siegel (2008) defines this transformation as a “metamorphosis” whereby students pass through a number of factors in terms of how they think about and practice design.

Personal process. While design is difficult to define in isolation, it may be due to the multiplicity of mental processes and frameworks that designers use to structure their personal design process (Notess & Blevis, 2004; Boling & Smith, 2010). In particular, the studio process can be seen as reinforcing the development of personal design knowledge (Yilmaz, Seifert, &

Gonzalez, 2010), which ultimately forms a personal problem solving strategy, or design process (Akalın & Sezal, 2009; Fincher, 1999) that they internalize and adjust over time (Pringle, 2009). Devoid of this process, the design student is left to externalized representations of design process (Blevis & Siegel, 2005), many of which overly linearize or simplify the design process (Lewis, 2005; Mawson, 2003; Smith and Boling, 2009; Teal, 2010).

Problem solving behaviors. Traditional problem solving strategies are targeted at well-defined problems, which are generally acknowledged to not exist in real world design problems (Breslin & Buchanan, 2008; Cross, 2007). Moving beyond the structure and strategies appropriate for a well-defined problem, a “wicked” problem has no direct solutions or standard methodologies that can be applied in a formulaic sense (Cross, 2001, 2007), although strategies can be used to push the designer in new, previously unconsidered directions (Lewis, 2005; Ludden, Schifferstein, & Hekkert, 2008). The willingness to accept the constraints indicated by these wicked problems (Dutton, 2006), along with the removal of the idea of a best solution or “right” solution as a possible outcome is key in the development of designerly thinking as it relates to problem solving (Siegel & Stolterman, 2008).

Evaluative Factors

Evaluation can be seen as a confluence of the previous three categories, as environmental factors, social factors, and formative cognitive functions mesh together in the basic evaluation activities of the design studio (Schön, 1988).

Public critique and feedback. Public feedback is the core of the design studio experience, creating opportunities to present design concepts, respond to peer and professor critique, and iterate the design appropriately to meet defined constraints and desired outcomes (Dutton, 1987; Schön, 1988). The public critique process is crucial to the development of design thinking (Blevis, 2010), and Walliss and Greig (2009) along with Danvers (2003) conclude that the indeterminacy and the lack of clear, unbiased feedback that often results from this approach encourages designers to think introspectively and further their intellectual development by questioning and being questioned.

Self-reflection. Wang and Ilhan (2009) note the importance of understanding how creative processes and their outputs relate to one another, even though each of these elements—whether it be design artifact, concept, or feedback—in isolation is not predictive of the next step in the creative process. This interaction between elements generates what Cross (2007) terms “the creative leap,” forming the next iteration in the design process, often without a clear link from previous design iterations (p. 65). While innovation is one of the defined causes of this “creative leap,” it is also a natural outcome of the self-reflection process and the linking of feedback, experience, and design knowledge (Crilly, 2010; Dorst, 2006; Wylant, 2008).

Peer and mentor support. In addition to the roles of self-reflection and public critique, peer feedback and mentoring also facilitate the overall goals of evaluation in the design studio (Schön, 1988; Oxman, 1999). Wang (2010) underscores the importance of peers and mentors being able to enter the design conversation and understand the design process and knowledge behind physical design prototypes, understanding and guiding each other through the iterative design process.

Synthesis of Factors

While each of these emergent categories of factors and associated elements are helpful in establishing an effective design studio, the core of the design studio is the evolving design student. As Siegel and Stolterman (2008) note, this transformational process to designer from non-designer is characterized by the penetration through a variety of barriers. It is through the overcoming of these barriers that individual design knowledge and process is developed, thereby giving the individual student the intellectual tools and practical experience to think in a designerly way. Shaffer (2007) describes an effective design learning environment as a “coherent system of activity,” (p. 100) not a collection of strategies or procedures that are only tangentially related. It is through this systems-view of design pedagogy that the importance of common elements such as social interaction, evaluation, and the creation of individual design knowledge becomes evident.

Purpose of Study

Graduate students with little or no design background who matriculate into programs of study within a traditional design discipline offer a unique viewpoint into the development of design thinking. These students often bring additional lived or educational experience from outside of traditional design education, which has the potential to add an additional dimension as compared to undergraduate students enrolled in design education. The development process, tracking the evolution from beginning design student to mature design professional, is affected by a number of factors, including those imposed by the design curriculum and faculty, as well as surface features of the design studio in which most design education is situated. The literature suggests a wide range of factors that may influence this development process from both of these sources, but is inconclusive as to how internal and external factors shape the individual designer as they complete the transition from novice to expert designer embodying patterns of design thinking.

Research Questions

1. What factors appear to restrict the ability of first year design students in their development of designerly thinking?
2. What factors do students report having a positive influence on the development of designerly thinking?

Method

This is a qualitative study, drawing on a critical theory methodology. The experiences of individual participants as reported from their vantage point is necessary to elicit responses for which the participants have tacit awareness (Carspecken, 1996). The longitudinally constructed interview format allows the participants to share and reflect on their experiences over a semester of coursework, creating a sufficient source of data to triangulate their experiences, changes in design thinking, and to establish factors that are not addressed by the current literature.

Setting

The study was conducted at a large midwestern university, focusing on students and faculty in a graduate design program in the School of Informatics. The Human-Computer Interaction design (HCI/d) Master's program trains future practitioners for careers in interaction design and user experience design. The program is generally completed within two years and is only available to residential students, who matriculate in a cohort of approximately 35 students. A majority of students come from a non-design educational background, including students with baccalaureate degrees in computer science and the liberal arts. HCI/d students take a variety of coursework, including intensive design practice and exploration of methods and theory, concluding with a design capstone project at the end of the second year. A shared studio space is available to all Master's students, but the space is not currently used for explicit studio-based instruction and lacks dedicated individual space for each student.

The Researcher

The researcher conducting this study is familiar with a variety of norms and behaviors in design education, having completed undergraduate and graduate coursework in graphic design, HCI/d, and instructional design in four distinct college environments. The researcher is familiar with the faculty and educational setting of the HCI/d department referenced in this study proposal, and has previously taken graduate coursework in this department. In addition to past experience in the HCI/d department, the researcher worked as a student mentor for first-year students in a foundational design course during the period of data collection. This mentoring included regular contact with students and student work, access to collaborative design meetings in which the students complete required projects, and participation in two out of three classes that were required by first-year students.

Participants

The participants in this study included six students from the HCI/d program. Participants were solicited through email, using a departmental list-serv established for first-year students in the HCI/d program. The protocol for inclusion in the study included accepting every other participant, judged by the order of their email response to the study solicitation. Because the number of participants requesting to be recruited to the study did not exceed the maximum allowable number, all potential participants were recruited into the study.

Data Collection

A series of three interviews were requested from student participants. These interviews were scheduled to allow for longitudinal data collection over the course of their first semester, placed at approximately the 9th, 12th, and 16th weeks of the semester. Each interview followed a semi-structured format (see Appendix A), with a duration of approximately one hour, and was audio recorded to allow for transcription and further analysis. Stimulated recall from previous interviews was used to allow for member checking of interview data and provide additional opportunities for reflection on past experiences by the participant.

Analysis

Data collected from student interviews were analyzed using the constant comparative method. A first round of analysis was conducted on the student interview data in isolation, dividing each set of interview transcripts from a specific interview in the longitudinal sequence into utterances representing a complete thought or idea. The utterances were then assigned to one or more categories that emerged from the data (Glaser & Strauss, 1999). A second round of analysis was conducted on the faculty interview data in conjunction with the established categories obtained in the first round of student interview analysis. My themes were informed by but not limited to the emergent themes addressed in the literature review.

A coding scheme was constructed during the process of analyzing multiple interviews for the presence of developmental progress, internal and external factors affecting their overall progress, and reporting of student's conceptions of design and their design process. The final coding scheme was applied across all student interviews, and codes were used in a non-exclusive scheme (i.e., one excerpt may be coded more than once). The final hierarchical coding scheme is provided in Table XX.

Table XX. Coding Scheme

Primary Code	Secondary Codes	Primary Code	Secondary Codes
Critique	In Class In Group Defend	Identity	Individual v. Group Individual to Group
Culture Shock	Communication Non-Native Speaker Personality	Background	Work History Undergraduate Education
Design Failure	Anticipation v. Execution Lack of Mentor Use Moved On/Checked Out Feature Creep Acknowledgement of Novice Status Incremental Progress Time Pressures Unfamiliar Tools	Group Work	Conflict Design Director Distance Work Expertise/ Leadership Group Formation Informal/Personal Relationship Work Distribution

Primary Code	Secondary Codes	Primary Code	Secondary Codes
Design Definition	Audience/User Constraints “Core” Holistic/“Whole Game” Iteration PRInCiPleS Problem Setting Process Outcomes/Product Rationale Research	Design Influence	1st v. 2nd Year Work 2nd Year Students/ Mentors Coursework Diversity Peers Precedent Professors Studio Features Tools/Methods

Findings are presented in two sections: the first describing the development of design thinking for each study participant, and the second discussing the factors that were found to impact the development of design thinking. Quotations from interviews will be noted by pseudonymous participant name, the interview round (R1, R2, R3) and the line numbers from the interview transcript (e.g., “Jonathan.R2.114-116”).

Design Development

The discussion of factors influencing the development of design thinking is predicated upon an evaluation of design change. I used the model of expertise proposed by Dreyfus, as reported along with additional work on expertise by Lawson & Dorst (2008) to evaluate the change in design thinking exhibited by each study participant. Each study participant (see Table XX) was asked to explicate their definition of design at the beginning of each interview, and in general, this served as good predictor of their design thinking (See Appendix XX). The first three levels of Dreyfus’ model (Table XX) are inclusive of the range of design thinking exhibited by these study participants, and the model notes that many working professionals never progress beyond the level 4 “expert” defined by the model (Lawson & Dorst, 2008).

Table XX. Student Participants

Participant	Gender	Country of Origin	Educational Background
Greg (JL)	Male	USA	Computer Science
Jonathan (TG)	Male	USA	Cognitive Science
Jessica (MR)	Female	USA	Anthropology
Jiao (ML)	Female	China	Engineering
Zhen (AG)	Female	China	Telecommunications
Xia (WT)	Female	China	Business

Table XX. First three levels of Generic Models of Expertise (Dreyfus in Lawson & Dorst, 2008, p.99)

Level
1. A novice will consider the objective features of a situation, as they are given by the experts, and will follow strict rules to deal with the problem.
2. For an advanced beginner the situational aspects are important, there is some sensitivity to exceptions to the ‘hard’ rules of the novice. Maxims are used for guidance through the problem situation
3. A competent problem solver works in a radically different way. Elements in a situation are selected for special attention because of their relevance. A plan is developed to achieve the goals. This selection and choice can only be made on the basis of a much higher involvement in the problem situation than displayed by a novice or advanced beginner. Problem solving at this level involves the seeking of opportunities. The process takes on a trial-and-error character, with some learning and reflection. A problem solver that goes on to be proficient immediately sees the most important issues and appropriate plan, and then reasons out what to do.

Greg

Greg began the program with a background in Computer Science, and had little formal design training, but had always felt a connection to sketching and other artistic forms of expression (R1.XX). Initially, he characterized design as “a very amorphous idea” and an “overall um direction or framework within which you know specific things found their place.” (R1.XX). This holistic sense of design was implemented into a design scenario in

prescribed way (“...understanding of like what you’re doing right now, how that fits into the project as a whole”, R1.XX) early in the semester, but quickly evolved into a more contextual or situational view, with Greg noting that “a large part of design is really getting in touch with the needs [...] or some sort of opportunity that people have” (R2.XX). By the end of the semester, he made linkages between the problem space and users (“really thoroughly knowing your problem space and being able to narrow it down to the areas that are important to your users”, R3.XX) and the role of trial-and-error in process (“obviously it’s not going to be a straightforward process to get there”, R3.XX). Using the Dreyfus model of expertise, Greg can be seen as progressing through novice in R1 to advanced beginner in R2, ending with a blend of characteristics of advanced beginner and competent in R3.

Zhen

Zhen completed her undergraduate work in telecommunications, followed by a year working for a company doing user interface design. She traveled to the USA from China for the first time to begin the HCI/d program. While she had previous work experience in a design field, she did not have competencies in exploring a problem space at the beginning of the semester (R1.XX). Early in the semester, her definition of design was holistic and experiential (“design will make your life easier and better, like to enjoy your life”, R1.XX and “apply that creativity to enjoy your life”, R1.XX), but lacking any specific implications for design process. As she advanced in the semester, she began to engage in a search for the design problem and solution (“we look at the problem, we want to find what’s the real problem”, R2.XX) and her team used methods to support their exploration of the problem space: “it’s like research is beginning to help us to frame the problem” (R2.XX). By the end of the semester, Zhen reiterated the lack of formal structure in her design process (“It’s not like a static or already decided the steps”, R2.XX) and the role of the specific situation in making design decisions: “...it’s like there is no specific plan for a design process, it just make decisions based on your current situation.” (R3.XX). Using the Dreyfus model of expertise, Zhen followed the more objective features of a novice early in the semester, advancing to aspects of advanced beginner and competent in R2 and R3.

I am unsure whether it is valuable to include a full biography of design development for each participant. I have the data to include this additional context, but left it out in the interest of space.

Factors Affecting Design Development

During the constant-comparative analysis of student interview transcripts, several categories of factors emerged. Some of these emergent categories were confirmatory of themes found in the design pedagogy literature, but others that emerged were absent or underrepresented in the existing design pedagogy literature. Both sets of factors will be discussed in detail.

Confirmed Factors

All of the general categories of factors that may affect the developmental process of design students were found in the interview data from this particular design program. Each factor

is discussed in a moderate amount of detail, including examples and context provided by the student participants.

Environmental factors.

Private and public space. The role of the studio space was readily accepted by most participants, after a brief period of adjustment and discomfort. Greg noted the environmental features that dominated the shared studio space, including “tables with multiple sitting positions” and “whiteboards everywhere for collaboration (R1.XX), while Zhen reflected on the studio space as a place for “others to come and say and give some advices. It’s really helpful.” (R1.XX). Not all initial or ongoing experiences with the shared space were positive, however, either because of noise (“it’s just loud”, Jessica.R3.XX) or lack of familiarity (“at first it’s kind of...not make me comfortable”, Zhen.R1.XX).

Contrast to traditional classroom space. The difference in teaching style or classroom configuration was not a topic of reflection, but the diversity of backgrounds shared by people in the cohort seemed to shape the space, as a reflection of each person’s unique educational and experiential background. Greg was surprised by “how crazy diverse people’s backgrounds are” when entering the program (R1.XX). Others capitalized on their backgrounds in contrast to others, with Jonathan discussing how his “cognitive science thinking is still influencing the way I think about things” (R1.XX) and Jessica valuing her undergraduate work, saying “...the biggest thing anthropology has given me is really in shaping the way I think about things” (R1.XX).

Unfamiliar tools and norms. This design program encourages the use of professional-grade sketching tools, and Jessica felt that “Marty likes us to use fancy tools um because it really does make me feel like I know what I’m doing” (R1.XX). But these tools and norms were still difficult for others to adjust to. Zhen was still struggling with sketching, sharing: “when I reviewed my notebook, I still find that (.) most thing on the notebook is words, not sketch” (R2.XX). Jessica was still struggling with the sketching process as well, reasoning that “I still don’t feel like I can really sketch in front of people, like that’s something I need to like take away and do at home” (R2.XX).

Complexity of technological tools. Because of the diverse background of students in the program, many participants struggled with new tools like Photoshop, Illustrator, and Axure (Greg.R1.XX; Zhen.R1.XX). Of particular interest was how the lack of tool expertise affected design output. Jessica noted “... what might be in your head, like you just don’t know how to use the tools to do that” (R2.XX), and Zhen regretted that “the final interface is not as beautiful as I imagined before” (R1.XX).

Social Factors.

Willingness to give and receive critique. Critique seemed to be difficult aspect of the design experience to accept, unless they had experienced it in their undergraduate education (Greg.R1.XX). In giving critique, the value of the critique was expressed as a factor to accepting it, with Xia concluding that “because the critiques we can um...we can stand up from where we fall down” (R1.XX) and Jonathan noting critique that is “most valuable is key, not the most...the one you wanted to hear the most” (R1.XX). In giving critique, personality seemed to play as a

factor, as Jiao noted: “I am good at critique, and I usually give too much critique, like very—the critique hard for people to accept” (R2.XX). The substance of critique was also important, with Jonathan reflecting: “I think asking questions in critique is an important way of getting...engaging design. I also think that working with teams and having those arguments and stuff like that is another way of critiquing.” (R1.XX).

Formative Factors.

Personal design knowledge. The program seemed to gradually influence the design thinking of participants. Jonathan was affected by exemplars, as he “started to understand like the design process and what’s not” (R2.XX), while Xia thought that “mentors and critique [...] help me to develop that design thinking. Maybe in an invisible way.” (R3.XX). Xia also reflected that the program “focus[ed] on design thinking, not using tools” (R1, XX).

Personal process. The formation of process was also a gradual evolution, with initial feelings of confusion (“I got really confused, because there’s no process [laughs] there’s no guidelines”, Zhen.R1.XX), followed by a feeling of concrete process (“There’s definitely a process and there’s definitely a way of doing things”, Jonathan.R2.XX), ending with a more open-ended realization (“It’s like there is no specific plan for a design process, it just make decisions based on your current situation”, Zhen.R1.XX).

Problem solving behaviors. In this design program, the concept of problem setting (Schön, 1983) as a form of problem solving was encouraged, and the students were given methods such as expansion and contraction to facilitate this process. Zhen felt like “when [she] learned the expansion/contraction process [she got] to the core of the design” (R1.XX), while Greg took a more holistic view later in the semester, noting the importance of “...really thoroughly knowing your problem space and being able to narrow it down to the areas that are important to your users, and then are important to you um and being able to address those issues...” (R3.XX).

Evaluative Factors.

Public critique and feedback. Like critique within the social factors theme, acceptance of this norm was initially uncomfortable, but was quickly seen as important as a source of feedback. In identifying public critique as different from other forms, Xia noted that “when a work is critique um publicly, yeah, um peoples words are more cogent than just critique within the table” (R2.XX). The after affects on the design project was also seen as important, with Jonathan recalling that his team was “basically dismantled at the end of Project 4 in that critique, which was—it was all great critique and it got us all thinking” (R3.XX), and Zhen’s team deciding “after the presentation [...] to change the [project] direction” (R3.XX).

Self-reflection. Some form of reflection was used by many participants as a way to reconcile with the work and people around them. Xia felt that reflection helped her “to examine that uh...what...what’s lack in my thinking pattern” (R1.XX), while Jiao liked “to learn from people, and they also give me a chance to reflect myself” (R2.XX). Reflection as a form of decision making was also important, as Zhen described that she “need[ed] to look at [her]

process and to reflect on it and to have a consciousness to make decision or what to do next” (R3.XX).

Peer and mentor support. This design program made extensive use of mentor support, both in an informal and formal capacity. Participants noted the importance of seeing second year expertise at work (“I just think really the hands-on experience and the modeling by the uh second year students has helped a lot.”, Greg.R3.XX), as well as in their specific design project (“... our mentor, helped us lot. And helped us trying to keep narrow down and to move forward.”, Zhen.R3.XX).

Additional or Under-Represented Factors

In the process of coding the interview data, several themes emerged that were not directly represented in the existing literature. In many cases, these additional themes seem to reflect the quantity (both in depth and time) of thick data collected from a specific design program, and the collection of data from a student-centric viewpoint. Some of these themes might represent a richer interpretation of an existing theme, such as the individual tensions that were identified around the process of critique, while others are contingent upon the specific application of design pedagogy applied in this HCI/d program. For instance, the assumption of group work in the primary design course that first year students were required to take framed not only the act of working in a group and fostering productive relationships, but also had ramifications on the development of a personal v. group identity, and issues of communication that result when working with non-native speakers or individuals with an unfamiliar educational background. Each primary theme I have identified is briefly described, including specific context or appearance in time, followed by dominant sub-factors that emerged during the coding process.

Group work. In this specific implementation of design pedagogy, group work is highly valued, both as a way of fostering professional and personal relationships, and as a “real-world” aspect of the curriculum, preparing students for future work in a collaborative design team. While group work is common in some areas of undergraduate education, many students shared a lack of familiarity with group work, or had negative past experiences. As the semester progressed, team work seemed to become more familiar, almost second-nature to some participants, while others developed an identity separate to their team experience (see discussion on Identity, below).

Importance of an informal/personal relationship. Project teams were initially assigned in the primary design course, and few students had established relationships prior to beginning the program. Starting with project 4, students were allowed to pick their own group members, and at this point, most students had the opportunity to work with a number of other students. As the semester progressed, the importance of establishing personal relationships with teammates as a path to effective group work emerged. Zhen noted that her teammates interacted in a variety of settings, “...not only meetings and just when we meet in hallways or yeah, we will talk and we will go to bar and talk more than others. Just makes me feel we are more intimate than others, and just feeling makes me feel good, and makes me feel easier to discuss and critique.” (R3.XX). Similarly, Jessica’s team often met at a local bar, and she found that “informal meetings are sort of the way to go and uh (.) well whenever we can, whenever it’s appropriate” (R3.XX). It

appeared that establishing personal lines of communication between group members allowed for more frank and honest discussion during group time, and led to a more productive design process.

Hiding ideas. Seen potentially in opposition to the importance of an informal/personal relationship, several participants felt that effective group work was facilitated by withholding personal feelings and opinions to establish group consensus. Zhen noted that “you have to (.) hide your ideas to fulfill other’s feelings” (R1.XX), while Jiao “[tried] to keep silence instead of um throw out my emotion to others” because she “wasn’t in the mood to talk about the conflicts or struggling things” (R3.XX). Other individuals seemed to “shut down” when they disagreed, with Jessica recounting that she “shut[s] down in groups whenever the conversation [...] whenever that starts to wander into a land I disagree with” (R3.XX). From an outside perspective, Jonathan also observes that “everybody has a great mind, great ideas, it’s just—they feel suffocated and they can’t show that.” (R2.XX).

Conflict. The potential for conflict in a group situation was addressed as an almost inevitable feature of group work, and as an outcome of expressing conflicting design opinions. These conflicts ranged from the mundane, where early in the semester, Jonathan and another group member “ended up arguing left and right about the way everything would look [...] it’s funny...it’s cliché to talk about where like a button should go” (R1.XX). But others engaged in conflict that threatened their team’s design process, with Xia’s observing that “[she] propose a vote and then uh like [they] divided to two groups and no one can convince each other and [she] think that the other’s idea is traditional and boring.” (R1.XX), while Zhen’s group engaged in conflict over ideas, as she describes: “Sometimes, I know I’m right, but when I insist on it—we just got a fight. I really couldn’t convince them. I don’t know why...” (R1.XX). Jiao experienced a less explicit conflict, but equally volatile, recounting that “...we didn’t actually have a fight with each other, uh, I just feel so uncomfortable in the meeting.” (R2.XX).

Culture shock. This program commonly includes a diverse cross-section of students, both in gender and country of origin. During the year in which this data was collected, almost half of the incoming cohort was comprised of non-native speakers—the highest level in the program’s history. While there are numerous resources available for international students on the university level, the transition to life in the USA was difficult for many students, including the three participants from China—none of whom had ever been to the USA before. Over the course of the semester, the ability of students to readily communicate in a fast-paced team setting improved, but this additional barrier often created added stress in an already busy semester. Although all of the study participants worked in teams with native and non-native speakers, only the three non-native speakers (Jiao, Xia, and Zhen) reported difficulties communicating and adapting to new personalities.

Ability to communicate. The need to communicate fluently and accurately was reported frequently by all three non-native participants. Jiao expressed that “it’s really hard for us to communicate—really communicate, like um, English is not my native language...” (R2.XX), while Xia experienced that “...most of the time is American talk to another American and they—both of them talk really fast [laughs]. So, sometimes it’s even hard for us to catch up their uh

speaking” (R2.XX). Communication of abstract concepts in a non-native language was often a barrier as well (“What really embarrass me is like when I try to express uh abstract ideas I can’t speak it clearly, I have to explain again and again and again”, Zhen.R1.XX), with the delay sometimes causing the group to shift before they really understood the concept (Zhen.R1.XX). The speed of communication was a reported issue (“...we cannot talk as fast as American...”, Jiao.R2.XX), as was the inability to effectively speak and think at the same time (“... sometimes I keep quiet not because I get lost, but because I’m thinking...”, Xia.R2.XX). Language issues persisted in groups with non-native speakers that did not share the same first language, as Jiao reported: “I think the biggest problem—one is our communication skills since we got three internationals in our team, it’s really hard for us to understand each other. Sometimes, I will say we spend more than 50% of our time to catch up with each other, and make sure everyone on the same page.” (R3.XX).

Personality. The adaptation of individual personality in a new setting also seemed to be shared issue. Zhen reflected that “when [she] was in China, [she was] the kind of person [that] like to talk” (R1.XX), while Jiao felt “kind of lost in America” (R3.XX). While there were some positive feelings associated with the shift (“Since I come here, I come I feel more free and I can do what I want.”, Jiao.R1.XX), the frustration sometimes led to isolation and frustration (“I feel really upset and really frustrated and I don’t even want to talk to any Americans.”, Jiao.R3.XX). Zhen also experienced a difference in culture as manifested in a group setting, expressing: “I think Americans are used to speak up and uh—to—to voice for themself and the Chinese are used to compromise.” (R2.XX).

Identity. Several individuals reported feelings of self, personality, preferences, and changes resulting from individual and group work in the design program. It seemed to be typical that an individual’s identity within the context of the design program was seen as growing in tandem with their design expertise, with the eventual outcome of professional design practice. In particular, there seemed to be a shift from individual to group, influenced by the large role of group work in the program. In opposition, however, some participants viewed themselves as separate from the group and expressed the need to develop further as an individual.

Individual to group orientation. Many students came into this design program with little experience either as a designer or as a member of a design team. The role of group work seemed to be valued once in the program, as Xia reflects that “I didn’t expect that teamwork is very important before I come here.” (R3.XX). However, group work often manifested a distribution of tasks based on individual or group comfort (“...sometimes we will sketch by ourselves and when we come back to discuss it...”, Xia.R1.XX; “... beforehand I think I want to hide my design before it is—before it is presented, but now I think it’s better to discuss the design with others as early as possible”, Xia.R3.XX), or students experienced group work as a blockage to deep thinking about a design problem (“...when people are trying to define their ideas [...] it’s hard to open the communication, but after we separate and think more deeply about it.”, Xia.R1.XX). Overall, the progression from individual to group work was couched in preparedness for industry (“...the way I see like our group projects right now, um I think that that’s more akin to like what happens in industry...”, Jessica.R2.XX), but the role of the individual was still seen as important

but difficult to grasp (“I don’t know how to like give like an individual focus [to projects]...”, Jessica.R2.XX).

Individual v. group. While the transition from individual to group work was largely seen as positive and reflective of work in industry, one participant seemed to see herself as an individual designer, distinct from group work. Jessica commented “...it’s sort of dawning on me that like there is myself as an individual designer and then like how I play in a group” (R2.XX), identifying these unfulfilled needs as an individual as important for group work (“whenever I have more time to uh to focus on [myself], I’ll be able to contribute to groups more...”, Jessica.R3.XX). This concept of knowing oneself as a designer and as a person seemed to figure into an overall of design pedagogy, with Jessica noting that “if somebody gives me a design challenge, I want to know myself a little bit better than I know myself right now, and know what I like...” (R3.XX).

Critique. While critique was located prominently in the literature, both as a social and evaluative factor, the personal view and experiencing of critique was often diminished in favor of perceived pedagogical value. Most students had little experience having their work critiqued, and so the transition to accepting critique—rather than merely defending their design—was a dominant theme. Also important was the role of giving critique, and the seeming inability of some participants to provide critique if they were unable to verbalize perceived flaws or provide a solution. Each of these factors is crucial to professional practice, and the tensions revolving around critique seem to mark inner insecurity around the role of critique as a formative tool to improve design.

Defend or accept? Early on in the design program, it is often unclear how to accept critique from other students or professors. The tension quickly developed between adequately defending your design and design process, and the importance of accepting critique as formative evaluation to continue improving the design. The instinct to defend the design seemed to stem from the public nature of the critique (“... because it’s not a casual conversations or...maybe it’s harder for me to accept this critique.”, Zhen.R2.XX), or the role of the individual designer’s judgement (“... of course you have your opinion about it [...] But, I will defend what I’ve designed and I will have an opinion about it.”, Jonathan.R2.XX). This defense gradually gave way to acceptance of critique over the course of the semester, with Zhen reflecting that “I am feel more comfortable to take those critique, but still I feel embarrassed...” (R3.XX) and “I’m trying to stop trying to defend it...” (R2.XX).

Reluctance to give critique. Another common reaction to critique was the unwillingness or inability to give critique to other students. Jessica seemed less willing to contribute to formal classroom critique, since she didn’t feel comfortable with public speaking (R2.XX), but also mentioned the role of feeling articulate, noting “I guess somebody else in the class is going to do [critique], and I already don’t think I’m the most articulate person, so I’m going to let somebody else pick up.” (R3.XX). Zhen shared that “At first I feel embarrassed” when critiquing other student work. Another common misunderstanding of critique was the role of critique as primarily a medium for sharing solutions. Xia observed “sometimes I just think, oh maybe there’s

something wrong with the work, but I can't [...] find the reason that..." (R2.XX), concluding that "...if I just raise a problems, I didn't give the solution, that mean I didn't help." (R2.XX).

Design Influence. Numerous factors were reported as directly or indirectly influencing the design process of participants. Many factors related to the environment of the shared studio space, or described the holistic notion of "the program" as influencing them as designers. But apart from the environment, most participants acknowledged the role of people as the most important factor in their development as a designer over the course of the semester. Three primary, but related factors were emphasized: 2nd year students, professors and mentors, and the synergy of coursework. All of these social encounters were mentioned numerous times by all participants.

2nd Years' work as precedent or benchmark. Every participant mentioned the importance of seeing work by more advanced students as beneficial in developing their own sense of process, and as a benchmark for their future work. Early in the semester, Zhen noted the potential benefit of working with 2nd years to learn more about the design process, both in how they design ("...I think I can learn more how [2nd years] design.", R1.XX), and how they work address design problems ("I think maybe it's a better way for us learn [...] to learn how [2nd years] deal with different problems.", R1.XX). The 2nd year work highlighted a gap between cohorts in terms of capability ("...seeing what the second years are doing [...] that's kind of highlighted what is lacking between first year and second year work.", Greg.R1.XX) and presentation ("...all second years seem very articulate. They can speak in front of a group...", Jessica.R3.XX). The role of 2nd year work as an exemplar or precedent also appeared to be potentially beneficial, as Jonathan reflects: "...I think it would be nice if it were actually put in front of you what an exemplar for submission looks like. What it—what it takes, right." (R2.XX).

Professor and peer mentor. The positive value of mentorship is well established in the literature, and this benefit was also clear in this design program. Mentorship was not always seen as helpful by participants, however, with the stated purpose of mentoring (to guide, not lead) by the professor coming in opposition to the desire for more direct assistance by students. Student mentors were assigned for each project in IDP, and other unassigned mentors were also available for additional consultation. Greg noted that their mentor "was trying not to be too strong, you know, like say do this." (R1.XX), while Zhen was frustrated by the lack of specific feedback, stating: "Because [the mentor] don't want us to follow his advice, so he just give some general guideline, but I don't think it is helpful." (R1.XX). Mentors also served a helpful role in critiquing projects, with some students finding mentor critique beneficial ("I think having the second years around is tremendously helpful, because in general, you can just grab anyone and be like, hey, what do you think of this?", Greg.R1.XX), and others noticing conflicting critique ("Just sort of totally different sides when it comes to mentor critique. So, we take it with a grain of salt. Almost all of it. At least I do.", Jonathan.R1.XX). By the end of the semester, participants were generally more accepting of the guiding model, with Zhen reflecting: "...our mentor, helped us lot. And helped us trying to keep narrow down and to move forward." (R3.XX).

The input from the professor, in particular the professor for IDP, was seen as valuable by all of the study participants. And in many cases, the expertise and critique of that professor was seen as different in quality, although tacitly, as compared to student mentors. The professor intervened in groups where he noticed difficulties arising, attempting to help them use more appropriate design methods (“...when [the professor] join in, we start he will get us to use the post notes to brainstorm and then to talk about this problems and to make a decision on it so we can move on to the next topics to expand it...to explore it.”, Zhen.R1.XX; “[The professor] had an intervention with us, like look guys, you guys are doing it wrong.”, Jonathan.R2.XX) or talk them through interpersonal conflicts (“I feel I don’t know how to improve it. That’s why I talked to [the professor].”, Jiao.R2.XX; “... we met [the professor] and he gave us some suggestions that uh (.) you can just ask everybody that if we can move on, then we present nothing Thursday.”, Xia.R1.XX).

Synergy of coursework. The alignment of coursework during the first semester of this design program appeared to be quite important in the overall conception of design and design process by students. The course Visual Literacy was being offered for the first time, alongside Interaction Design Practice (IDP) and Foundations of HCI. IDP offered a primary design experience, with group projects and an emphasis on practice. Foundations was primarily a reading class, which used the structure of “three waves” of HCI to talk about divisions of HCI research from business application to multi-user systems to hedonic qualities of interaction. Visual Literacy focused on developing design judgement and the ability to critique and understand visual materials. The sharing of information between courses was clear, with participants noting value for future design work (“Jeff’s class give me the—a holistic view of HCI. And—I don’t think it’s helps my design process directly, but maybe I feel like it will help me a lot in the future.”, Zhen.R2.XX), immediate value for research (“...before I— read this paper [in Foundations], I not think about search ubiquitous computing.”, Zhen.R2.XX), and explanation of features of the design pedagogy (“...emotion from my—myself can also influence what—what I am doing. Like it’s a circle things, like when Jeff is talking about um emotions should be a priori to reason, I feel like the same way.”, Jiao.R3.XX). The contrast of individual and group assignments between Visual Literacy and IDP was also important, both in feelings of success (“I feel—a lot more in control of the products for Eli’s class.”, Jessica.R1.XX), and the ability to apply visual knowledge to presentations (“I know, you can see the changes in our presentation”, Zhen.R2.XX; “[Visual Literacy] has brought me a lot of value in um (.) thinking critically about the choices I make in the PowerPoint presentation...”, Jonathan.R3.XX).

Limitations of Study

In this study, I have investigated the development of design thinking from a student perspective in a specific instantiation of design pedagogy. As such, none of these results should be seen as directly transferable or generalizable to other design programs, disciplines, or even future iterations of this specific program. However, themes that have been identified in this analysis of a specific design program may provide further direction for future research and study.

Because of the qualitative nature of this research study, the specific implementation of design pedagogy becomes an important feature for analysis. While the literature generally speaks

of pedagogical features in concrete, transferable form, a specific design pedagogy context is intensely situated, drawing from a wide range of non-replicable features, including: coursework and professors, composition of the cohort, state of research and practice in the field, availability of precedent in the mass market, and issues specific to the studio and/or learning environment. As such, no single design pedagogy instance is completely replicable, which underscores the importance of investigating these features and their role in the learning process.

Conclusion

The tradition of design pedagogy within the studio has evolved over the past century, adapting to changing orientations of design practice, perceived need, and logistical demands of the educational process. As the design studio model continues to be adapted and applied to emerging fields, and as the core design disciplines change in focus and breadth, an understanding of how design students are affected by the studio model in specific terms is critical to the ongoing effectiveness of the studio.

In this study, I have outlined a series of factors that were found to influence students in a specific implementation of design pedagogy, including the role of group work in shaping a wide range of pedagogical features, the implications of culture shock in diverse educational settings, the importance of building a personal and group identity within the context of design, the social pressures of critique, and the wide range of design influence created by the alignment of curriculum, professors, and mentors/peers. Each of these aspects of learning within a design pedagogy context represents a potential area for research and further study. As design as a signature pedagogy is implemented into additional disciplines, a holistic understanding of the studio, and by extension the design learning environment as a “coherent system of activity” (Shaffer, 2007, p. 100) is indispensable. Without knowledge both of the complete system and the factors within the system that cause this signature pedagogy to function, we risk misunderstanding the reasons for past success of this learning structure in the rush to incorporate elements of this pedagogy in new disciplines.

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Appendix A

Student Semi-Structured Interview - First Interview

1. What previous experiences have you had as a designer (either professionally or personally)? What is your academic background? Work history?
2. Before you began the program, how would you have defined the term “design” in a general sense? In your specific discipline?
3. Before you began the program, what external or internal factors affected the design process for you?
4. Tell me about a design project you have worked on in the past. What frustrations and/or successes can you recall? [Why do you think the project/class/program was designed that way?]
5. If you have worked on a design project as a team in the past, how did you interact with other people? What role did they play in the design process?
6. Up to the point in which you began the HCI/d program, what factors (personal, professional, educational, etc.) shaped you the most as a designer?
7. How would you define the term “design”?
8. What external or internal factors affect the design process for you?
9. Tell me about a design project you have worked on so far this semester. What frustrations and/or successes can you recall?
10. What role has teamwork played in your design education this semester, if any? How did the team affect the design process?
11. Have you had the opportunity to participate in critique, or have you had your design work critiqued? Tell me about that process.
12. What factors have influenced you the most in your design process or as a designer so far this semester?

Interviewer will ask probing questions to follow up on participant responses.

Student Semi-Structured Interview - Second and Third Interviews

1. How would you define the term “design”? How has your perception of design changed since our last interview?
2. What external or internal factors affect the design process for you?
3. Tell me about a design project you have worked on so far this semester. What frustrations and/or successes can you recall?
4. What role has teamwork played in your design education this semester, if any? How did the team affect the design process?

5. Have you had the opportunity to participate in critique, or have you had your design work critiqued? Tell me about that process.

6. What factors have influenced you the most in your design process or as a designer so far this semester?

Interviewer will ask probing questions to follow up on participant responses.

Appendix B: Design Definitions by Participant

Participant	Round 1	Round 2	Round 3
Greg	“So I think design to me is a...is an overall concept, was very amorphous idea, for sure, but um. (.) Kind of just some intelligent overall um direction or framework within which you know specific things found their place.” (R1,)	“a large part of design is really getting in touch with the needs or the uh—a need or some sort of opportunity that people have, you know, that people necessarily have identifying that need or that problem, and identifying the people who um would benefit from that” (R2,)	“getting an overview on understanding all of the connections and just kind of understanding the whole picture of the problem you’re looking at, really thoroughly knowing your problem space and being able to narrow it down to the areas that are important to your users, and then are important to you um and being able to address those issues, you know, in the best way, using research and insights and all the tools we have.” (R3,)
Jonathan	“design is looking at how people and systems and things can work together and coming out with a product” (R1,)	“There’s definitely a process and there’s definitely a way of doing things, like you do have to start with an exploration of a space and you kind of have to (.) figure out where you are and then you go through the motions and narrowing down and you—it’s all about working with a team and like coming out like, you know, something at the end that you can be proud of.” (R2,)	“I think design is something that you have a bunch of people and these people have a problem. They—they may not necessarily know it’s a problem, but they do have needs or something that needs to be asserted towards that problem. So design is really understanding the problem, finding some sort of opportunity within that problem, and then coming up with a solution.” (R3,)
Jessica	“Like, the word design by itself doesn’t mean anything to me. Like, you have to apply it to something, like industrial design or what we do in HCI or interior design or fashion design. But design by itself is very nebulous.” (R1,)	“I’m starting to think of it like design for design’s sake and like, maybe it comes from—it’s rooted in those disciplines, but I don’t know. There’s some other like designerly epistemology that comes from those.” (R2,)	“well I think of what it was, like that design for me is like, I usually think about it more in terms of like designing an actual object or the space, some sort of industrial design” (R3,) “I’m trying to think about how I like answered it before, cause like all I can think of to say right now is huge iterative process, focuses on users, um I’m thinking of our whole game sketches.” (R3,)

Participant	Round 1	Round 2	Round 3
Jiao	<p>“what design is um is to create or improve the things you want to help people.” (R1,)</p> <p>“a designer can create something new, something novel for people, for life, for society” (R1,)</p>	<p>“the designer’s job is not about to design a product, it’s about to design for human life. Like for people, especially. We are dealing with problem like when we were designing, we are dealing problem with our teammate. And after we design it, we are dealing with problem about um how it affect to the community. And before that we are thinking about problem of people, like how they—how they interact with each other and um what they need. Like all the things that they’ve done, it’s all about people.” (R2,)</p> <p>“And I consider a designer is the person who can see the bigger thing instead of just system engineer or—” (R2,)</p>	<p>“now I would consider that design isn’t an activity or about human beings. Um, maybe we—it’s not only about um aesthetics, but also about um, what say (.) between (.) no, inter and outer of human beings and environments, I would say. Like um, being curious about human, we also curious about the environment that human were in. And um (.) maybe in sentence we want to make the world better. In terms of human beings.” (R3,)</p>
Zhen	<p>“I just feel like design will make your life easier and better, like to enjoy your life.” (R1,)</p> <p>“It’s like apply that creativity to enjoy your life.” (R1,)</p>	<p>“we’re trying to find the...look at the more para-level of the research, we look at the...what do you say this, like, we look at the problem, we want to find what’s the real problem. It’s like, it’s now look at their other solution, it’s like we want to define the problem ourself and to figure out what is the most appropriate solution. So it’s like research is beginning to help us to frame the problem. So, I think that’s the most different part.” (R2,)</p> <p>“It’s not like a static or already decided the steps.” (R2,)</p>	<p>“it’s like there is no specific plan for a design process, it just make decisions based on your current situation. It’s like according to this research, so we made plan to do a further primary research or maybe we will go into design process or maybe we just come up with our core, or something like that. But it’s—it’s depend on the situations, knowledge we have get and uh the analyze result, you generate from a [inaudible] knowledge and yeah.” (R3,)</p>
Xia	<p>“create a new way of thinking (.) to...I can. think of the most broad, uh, the most broad concept I think is to make life better.” (R1,)</p> <p>“just let imagination go wild.” (R1,)</p>	<p>“design now for me is um critique and iteration. Yes, and (.) hmm (.) during the critiques, we uh gather other’s opinion and uh makes some changes of our previous thoughts. And then we keep iterating and critique, yeah, and then come up with a final design.” (R2,)</p>	<p>“I would say design is (.) iteration” (R3,)</p>