Factors That Shape Design Thinking

Colin M. Gray, Indiana University Bloomington, USA

RESEARCH

Abstract
A wide range of design literature discusses the role of the studio and its related pedagogy in the development of design thinking. Scholars in a variety of design disciplines pose a number of factors that potentially affect this development process, but a full understanding of these factors as experienced from a critical pedagogy or student perspective is lacking. In this study, the experiences of six first-year design students were examined as they evolved in their conceptions of design. Data was collected during a series of three interviews. Analysis of data confirmed and recontextualized factors identified in the literature. Additional factors relating to group work, culture shock, critique, individual versus group identity, and the design influence of professors, mentors, and curricula are identified and reported. Opportunities for future research are identified.

Personal and Pedagogical Factors That Shape Design Thinking

Design as a recognized discipline and method of inquiry has increased in scope and breadth, while the focus of design pedagogy has shifted to recognize and adapt to digital methodologies and react to factors encountered in traditional design learning. Studio design pedagogies have adapted over time through the differentiation of design disciplines (Findeli, 1990), but the blending of functional and structural elements in a problem solving orientation are relatively consistent across a wide variety of design disciplines (Brandt et al. 2008; Kuhn, 2001). Even though a core design pedagogy has been widely implemented across these disciplines, the process of moving a student toward mastery, including changing the way they think about design (Cross 2011; Siegel and Stolterman 2008), is not well understood. In this study, the experiences of first-year design students were identified and evaluated in order to understand factors that shaped their design thinking. The perspective of the researcher in this study can be framed in terms of critical pedagogy, which Dutton (1991) describes in his evaluation of the "hidden curriculum" in architectural education as the "unstated values, attitudes, and norms which stem tacitly from the social relations of the school and classroom as well as the content of the course" (p. 167). This study also explicitly takes the standpoint of the design student and their experience within the pedagogy, drawing on the perspectives of Anthony (1991) and Willenbrock (1991) to gain a richer understanding of the student experience.

To address this critical perspective, this study focuses on identifying the factors that appear to affect first-year design students in their development of designerly thinking during their first semester of graduate education.

The discussion is first grounded with working definitions of design thinking and the studio, and then report the findings of an extensive literature review on factors that may shape design thinking. Based on the factors found in the literature review, the experiences of six first-year design students enrolled in a Human-Computer Interaction (HCI) program will be discussed, including the array of factors that affected their evolving conceptions of design during their first semester of graduate study. This discussion includes evaluation of gaps in the current literature and productive paths for future research.

Review of Literature

Design disciplines 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, peer and instructor critique, and minimal direct instruction. The design studio is typically structured on the enactment and modelling of design thinking, whereby individuals 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 and Smith, 2010; Brandt et al., 2008; Breslin and Buchanan, 2008; Shaffer, 2003; Teal, 2010). Design thinking, as proposed by Cross (1982), includes four important features: it is constructive in nature, it addresses ill-defined problems, it is solution-focused, and it is dominated by problem solving.

Schön (1987) presents the design studio as an environment where projects are individually or collaboratively executed, and where projects are selected based on their applicability and conformance to the practice of a given design discipline. The design studio and its pedagogy are bound together in this review for practical reasons, 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.'

A literature review was conducted to establish potential factors that may shape a student's development of design

thinking. The identified literature includes research on the application of the studio pedagogy in a variety of design disciplines including: computer science, interaction design, architectural design, instructional design, graphic design, and engineering design. Literature from these design disciplines was searched using multiple keywords relating to the design studio and design pedagogy across a range of research databases. In addition, the accretive method of 'snowballing' identified additional literature that was commonly cited in the overall discourse of design pedagogy. From this corpus of literature, candidate themes of factors that are informed by design pedagogy were identified through a thematic analysis, and these themes form the tentative outline of factors that follows. This framework will be used as an entry point to discuss the experiences of six individual design students in their first semester of design education, and as a way to contrast the current state of the literature and the complexities of these individual paths to design competency.

Four main categories of factors were identified during the thematic analysis, including: 1) environmental factors, 2) social factors, 3) formative factors, and 4) evaluative factors. Each category is discussed in turn:

1. Environmental Factors

Environmental factors include the composition of the studio itself, both the physical space and resources and the pedagogy that occurs within the design studio, as well as the tools used by students within the context of the studio. The studio is often assumed to be a well-defined physical location, drawing on decades or centuries of practice in established design disciplines. However, in many new studio programs, a lack of dedicated space can be problematic (Blevis et al., 2004; Reimer and Douglas, 2003). A mix of public spaces and defined private work areas seems to meet the needs of the design studio most efficiently, providing common areas for critique and peer interaction, while allowing students to work in a consistent, self-defined space (Reimer and Douglas, 2003; Wang, 2010). It is less clear, however, whether all of these components are vital for a functioning design studio. Shaffer (2003) suggests that the 'surface features' of a physical space, which can include 'time, space, resources, and materials' (p. 4), partially form the overall pedagogical experience, and that these features can affect the kinds of activities that the studio can support.

Within the design studio space, students on the graduate and undergraduate levels unfamiliar with a studio pedagogy may be uncomfortable due to the lack of apparent structure or traditional classroom practice (Burghhardt and Hacker, 2004; Demirba and Demirkan, 2003; Ochsner, 2000). This initiation to the studio model can be especially problematic for graduate students entering a design discipline from a field outside the traditional design experience (examples include: Boling and Smith, 2010; Siegel and Stolterman, 2008). These students are often more familiar with direct instruction or other more traditional modes of teaching. Shaffer (2003) discusses the role of pedagogical factors within the studio, encapsulating formal instruction, activities, and assessment. These formal pedagogical mechanisms represent the planned curriculum of a given design studio. A student unfamiliar with the design studio might also be potentially frustrated by the difference in tools with which to express themselves (Mawson, 2003; Ochsner, 2000). In place of note taking and textbooks, a design studio is most frequently oriented towards sketching (Buxton, 2007; Lee and Breitenberg, 2010) and rapid prototyping (Akalin and Sezal, 2009; Dutton, 1987), which may require a range of specialized tools. Any combination of these tools, which eventually allow for thoughts to be quickly captured for quick iteration (Lee and Breitenberg, 2010; Mawson, 2003), require mastery in isolation prior to being useful in the ideation process (Norman, 1998).

2. Social Factors

Social factors within the studio include interactions with peers, professors, and design professionals. Along a negative dimension, these interactions might manifest in discomfort when working with peers or openly receiving feedback (Siegel and Stolterman, 2008), or in the creation of protective mental structures or design processes (Ochsner, 2000) that limit the progression of a student. While some design disciplines are still focused on isolated, individual work (Webster, 2008), the introduction of collaborative group work requires a willingness to break rules in an organized sense to encourage innovation (Gregory, 2003; Wylant, 2008), and the willingness to engage social interaction in an organized, consensus-oriented way.

Within the studio environment, the core social activity is the critique process, the giving and receiving of critique, that surrounds the design production process (Blevis, 2010; Hokanson, 2012). The design studio is founded upon a culture of open critique (Wang, 2010). and critique both between peers and between students and professors can encourage 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 and Edmonds, 1996). As a corollary to the process of accepting critique, questions asked during a formal or informal critique often serve a pedagogical purpose,

spurring new or previously unexplored lines of thought from studio participants (Logan, 2008). Designers must be willing to accept regular critique in the design studio environment, moving beyond the mere pedagogical presence of critique to an individual commitment of acceptance and engagement (Danvers, 2003; Pringle, 2009). In this critique process, the student can interact with the instructor to justify their actions by telling and showing (Demirba and Demirkan, 2003; Schön, 1983), but evaluation can sometimes 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 stages of pre-emergent thinking and designerly thinking.

3. Formative Factors

Formative factors describe how a student tends to think about the design discipline, or how the student would describe or explain their relationship to or knowledge of design. The goal of the design studio is to produce students who 'think' like someone in that design field (Cross, 2011; Ledewitz, 1985; Oxman, 1999). Mapping the progress of an individual student to this general norm is less clearly defined, even to a successful design student or practitioner (Yilmaz, Seifert, and 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 series of barriers in terms of how they think about and practice design. Beyond a pedagogical model of development, Lawson and Dorst (2009) cite Dreyfus' generic model of expertise, which posits a six-stage model moving from novice to visionary.

Design students use numerous mental constructs and frameworks to structure their design process (Boling and Smith 2010; Notess and Blevis 2004). Engagement in the studio can reinforce the creation of design knowledge and frameworks (Yilmaz, Seifert, and Gonzalez 2010), which ultimately forms a design process (Akalin and Sezal 2009; Fincher 1999) that students internalize and adjust over time (Pringle 2009). Devoid of this process, the design student is left to externalized representations of design process (Blevis and Siegel 2005), many of which result in linearization or simplification (Lewis 2005; Mawson 2003; Smith and Boling 2009; Teal 2010). When engaging a student's design process in the actual activity of designing, this process must address 'wicked' problems that have no direct solutions, where standard methodologies cannot be applied in a formulaic sense (Cross, 2001, 2007).

In contrast, traditional problem solving strategies are targeted at well-defined problems, which are generally acknowledged to not exist in real world design problems (Cross, 2007; Breslin and Buchanan, 2008). Strategies embedded in a student's design process can be used to push the designer in new, previously unconsidered directions (Lewis 2005; Ludden, Schifferstein, and Hekkert, 2008), and a willingness to accept the constraints indicated by wicked problems (Dutton, 2006), along with the removal of the idea of a best solution is critical to the development of designerly thinking (Siegel and Stolterman, 2008).

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 evaluation activities of the design studio (Schön, 1988). 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. Common evaluation strategies within the studio, including public critique, individual reflection and iteration, and peer feedback/mentoring, reveal this coherence across the environment of the studio, social interaction between peers and professors, and the formation of a personal conception of design and design process.

Public feedback, normally manifesting in formal critique, is the core of the design studio experience. This feedback includes the provision of opportunities to present design concepts, respond to peer and professor critique, and iterate the design appropriately to meet defined constraints and desired outcomes (Anthony, 1991; Dutton, 1987; Schön, 1988). The public critique process is crucial to the development of design thinking (Blevis, 2010), and Walliss and Greig (2009) and Danvers (2003) conclude that 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.

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; design artefact, 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 element of this 'creative leap,' the development of a

design is also a natural outcome of the self-reflection process and the linking of feedback, experience, and design knowledge (Crilly, 2010; Dorst, 2006; Schön, 1983; Wylant, 2008).

Peer feedback and mentoring 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. The social environment of the studio informs these opportunities for feedback and mentoring, including a culture of critique and regular communication between students.

While these emergent categories of factors are helpful in understanding the features of a design studio, the focus of the design studio is the evolving design student. As Siegel and Stolterman (2008) note, this transformational process from non-designer to 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.

Purpose of Study

Graduate students with little or no design background who matriculate into a design discipline offer a unique viewpoint into the nature and experience of learning within a design studio. These students often bring additional lived and educational experience from outside design education. The literature suggests a wide range of factors that may influence the development of these students as designers, but is inconclusive as to what factors shape the individual designer during their educational experience from a critical pedagogy or student perspective (Dutton, 1991; Willenbrock, 1991). To address this critical perspective, this study focuses on the following research question: What factors appear to affect first year HCI design students in their development of designerly thinking during their first semester of graduate education?

Method

This is a qualitative study, drawing on critical theory as applied through a critical pedagogy perspective (Dutton, 1991). 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). Longitudinally constructed interviews allow participants to reflect on their experiences over their first semester of design education, creating a sufficiently thick source of data to describe their experiences and document changes in behaviour or thought process.

Setting

The study was conducted at a large Midwestern USA university, focusing on students in a graduate design program in a School of Informatics. The HCI design Master's program targeted in this study trains students for careers in interaction and user experience design. A majority of students matriculating into this program come from a non-design background, including students with undergraduate degrees in computer science, anthropology, cognitive psychology, and journalism. This program recruits a diverse group of students across a number of dimensions, including gender, work experience, and country of origin. Students take a wide range of courses in their Master's experience, including: intensive design practice, exploration of methods and theory, seminal readings, prototyping, and a design capstone project at the end of the second year. During their first semester of graduate study, the students in this study took three required courses: 1) an intensive interaction design practice course, with introduction to basic design concepts through five substantial design projects; 2) a digital literacy course, instilling a background in visual principles of design and use of creative tools; and 3) a foundational readings course, including seminal readings in HCI.

The Researcher

The researcher conducting this study completed undergraduate and graduate coursework in graphic design, HCI, and instructional design, and worked as a student mentor for first-year students in their interaction design practice 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 completed required projects, and participation in two out of three classes (interaction design practice and foundational readings course) that were required of first-year students. Although no explicit field notes were taken during these experiences, regular collaboration with students allowed the researcher a high degree of familiarity with student experiences and project work from which to base interview questions.

Participants

The participants in this study included six first-year students from the HCI program (Table 1). Participants were solicited through email, using a departmental list-serv established for first-year students in the HCI program. All responding participants were recruited into the study.

Student Participants.			
Participant	**Gender**	**Country of Origin**	**Educational Background**
Greg	Male	USA	Computer Science
Jessica	Female	USA	Anthropology
Jiao	Female	China	Engineering
Jonathan	Male	USA	Cognitive Science
Xia	Female	China	Business
Zhen	Female	China	Telecommunications
Note: all participants are referenced by an assigned pseudonym.			

Table 1

Data Collection

A series of three interviews were conducted with student participants. These interviews were placed at approximately the ninth, twelfth, and sixteenth weeks of the first semester. Each interview had a duration of approximately one hour, and was audio recorded to allow for transcription and further analysis. All interviews followed a semi-structured format, with questions including: the student's current definition of design, discussion of design projects they had worked on recently, their participation in critique, and factors they felt were most influential in their development as a designer. These questions were based on themes identified in the literature, including the participant's conceptions of design (Cross, 2011) and concrete experiences originating in the design curriculum or personal experience (Willenbrock, 1991). Follow-up questions were used to engage the participants in a rich discussion of their experiences both in and out of the classroom, including personal factors that may have affected their overall graduate design program experience. Stimulated recall from previous interviews was used to allow for member checking of interview data and provide opportunities for reflection on past reported or observed experiences by the participant.

Analysis

Data collected from student interviews were transcribed in their entirety by the researcher and analysed using the constant comparative method. Each interview was divided into utterances that represented a complete thought or idea. The utterances were then assigned to one or more themes that appeared to be consistent with the data (Glaser and Strauss, 1999). The final themes were informed by, but not limited to, the themes addressed in the literature review. An open coding scheme was constructed during the process of analysing multiple interviews. After the identification of approximately 90 non-hierarchical potential codes through a process of close reading and subsequent application of candidate themes, these codes were then merged, renamed where appropriate, and organized into a hierarchy of primary and secondary codes. The final coding scheme included eight primary codes and 45 secondary codes; five of these primary codes along with related secondary codes are reported in this document (Table 2). This final coding scheme was applied non-exclusively across all student interviews (Table 2).

Coding Scheme.	
Primary Code	Secondary Codes
Group Work	Conflict; Design Director; Distance Work; Expertise/Leadership; Group Formation; Informal/Personal Relationship; Work Distribution
Culture Shock	Communication; Non-Native Speaker; Personality
Identity	Individual v. Group; Individual to Group
Critique	In Class; In Group; Defend
Design Influence	First v. Second Year Work; Second Year Students/Mentors; Coursework; Diversity; Peers; Precedent; Professors; Studio Features; Tools/Methods

Table 2

Findings

During the analysis of student interview transcripts, several categories of factors were found to be consistent across multiple student experiences. Some of these categories were confirmatory of themes addressed in the initial literature review, but other emergent themes were absent or underrepresented in the literature. All of the themes identified in the literature review were found in the interview data.

The additional emergent 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 (Willenbrock, 1991). Some of these themes may 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 program. For instance, students were required to work in groups in the interaction design practice course during their first semester. This requirement of group work was framed by the pedagogy, but also had a significant effect on the development of a personal v. group identity through a fostering of productive collaborative relationships. This pedagogical requirement also surfaced issues of communication that often result when working with non-native speakers or individuals with an unfamiliar educational background.

Several emergent themes that were absent or underrepresented in the reviewed literature will be identified, and each theme will be described as it was represented in the experiences of the design students. These individual experiences represent layered and often conflicting notions of core design issues, which indicate the need for additional targeted research from a critical perspective. Each quotation is referenced by interview round (e.g., R1, R2, R3), to place the student's experience in the context of the overall semester.

Group Work

In this specific design program, group work is highly valued; both as a way of fostering professional and personal relationships, and as preparation for work in a professional design team. Many students shared a lack of familiarity with group work, or had negative past experiences, but as the semester progressed, group work seemed to become more familiar. Others chose to develop an identity separate to their team experience, while others identified primarily as a team member rather than an individual designer.

Project teams were initially assigned in the primary design course, and few students had established relationships prior to beginning the program. Starting in week seven, students were allowed to pick their own group members, and at this point, most students had worked with a number of other students in this primary design course, or in other courses. 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). 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). It appeared that establishing personal relationships between group members allowed for more honest discussion during group work, and led to a more productive and rewarding design process.

Although meetings sometimes fostered intimate, honest relationships with peers, 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), 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). Other individuals seemed to 'shut down' when they disagreed, with Jessica recounting that she 'shut[s] down in groups whenever the conversation [...] starts to wander into a land I disagree with' (R3). From another perspective, Jonathan observed: 'everybody has a great mind, great ideas, it's just, they feel suffocated and they can't show that' (R2). This lack of true group consensus and honesty often resulted in conflict as the design process evolved. This potential for conflict in a group situation was addressed as an almost inevitable feature of group work, an outcome of expressing conflicting design opinions. These conflicts ranged from the mundane, ('We 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,' Jonathan.R1) to complete stalemate ('[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,' Xia.R1). 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). Jiao

experienced conflict as lack of comfort: 'we didn't actually have a fight with each other, uh, I just feel so uncomfortable in the meeting' (R2). These conflicts seemed pervasive as a by-product of requiring collaborative group projects, and while encouraging intimacy and community among peers in many cases, these projects also forced students to develop patterns of communication that emphasized rigorous honesty.

Culture shock

During the academic year this data collection took place, almost half of the incoming cohort was comprised of non-native speakers, the highest level in the program's history. While numerous resources are available for international students, the transition to life in the USA was difficult for many students, including the three participants from China, none of whom had been to the USA previously. As the semester progressed, the ability of students to readily communicate in a team setting improved, but this additional barrier often created added stress in developing a shared understanding. Although all of the study participants worked in teams with native and non-native speakers, only the three non-native speakers reported difficulties communicating and adapting to new personalities.

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' (R2), while Xia recounted 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). Communication of abstract concepts, a dominant part of most design conversations, 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), with the delay sometimes causing the group to shift before they really understood the concept. The speed of communication was a reported issue ('we cannot talk as fast as American,' Jiao.R2), 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). 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).

The adaptation of individual personality in a new setting also seemed to be an issue. Zhen reflected that 'when [she] was in China, [she was] the kind of person [that] like to talk' (R1), while Jiao felt 'kind of lost in America' (R3). 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), 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). Zhen also experienced a tension in a group setting, with the conjecture: 'I think Americans are used to speak up and uh—to—to voice for themself and the Chinese are used to compromise' (R2). During this first semester, international students seemed to be developing a mental model of how they should interact with American students, with their personal identity or personality often intentionally altered during this coping process.

Identity

Several individuals reported feelings about 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 as a designer within the context of the program grew in tandem with their design expertise. In particular, there seemed to be a shift from individual to group identity, possibly influenced by the large role that group work played in the curriculum. However, some participants viewed themselves as separate from the group and expressed the need to develop as an individual.

Many students came into this design program with little experience as a designer or as a member of a design team. The role of group work seemed to be valued once enrolled, as Xia reflects: 'I didn't expect that teamwork is very important before I come here' (R3). However, group work often included distribution of tasks based on individual competencies ('sometimes we will sketch by ourselves and when we come back to discuss it,' Xia.R1; beforehand I think I want to hide my design before it is…presented, but now I think it's better to discuss the design with others as early as possible,' Xia.R3), or students experienced group work as a barrier to deep thinking about a 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). 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), 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).

While the transition from individual to group work was largely seen as positive and reflective of work they would be likely to do as a design practitioner, one participant seemed to see herself almost exclusively 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), identifying these unfulfilled needs as an individual as important for group work ('whenever I have more time to focus on [myself], I'll be able to contribute to groups more,' Jessica.R3). This concept of knowing oneself as a designer seemed to figure into an overall perspective on design pedagogy, with Jessica noting: 'if somebody gives me a design challenge, I want to know myself a little bit better than I know myself right now' (R3).

Critique

While critique was located prominently in the literature, both as a social and evaluative factor, the experience of critique was often diminished in this program due to perceived pedagogical value. Most students had little experience engaging in critique, so the transition to accepting critique, rather than defending their design, was a dominant theme. Also important was giving critique, and the seeming inability of some participants to provide critique if they were unable to communicate flaws or provide a solution. These tensions regarding critique seemed to mark student insecurity around the role of critique as a tool to improve design, and their perceptions of this tool varied widely between formal and informal contexts.

Early on in the design program, it was unclear how students should accept critique from other students or professors. The tension quickly developed between adequately defending your design and design process, and accepting critique as formative evaluation to improve the design. The instinct to defend a 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), 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). This defence gradually gave way to acceptance 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) and 'I'm trying to stop trying to defend it' (R2). The experiences that drew a defensive reaction were almost entirely public classroom critiques, while private, informal critiques in the studio were met with a more accepting disposition. While the formal literature does not directly address informal critique among peers, this type of critique was frequently alluded to by most of the participants.

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), 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). 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), concluding 'if I just raise a problem, I didn't give the solution, that mean I didn't help' (R2). While several participants noted reticence to give critique in a public context, almost all of the participants referenced giving critique in informal settings such as the studio, email, or social networking tools.

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, or related to the formal curriculum (or 'the program') as influencing them as developing designers. Apart from the physical 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: communication or relationships with second year students for benchmarking or critique, the role of professors and mentors as design leaders, and the synergy of coursework. Each of these factors were mentioned numerous times by all participants.

All participants 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 second years to learn more about the design process, both in how they design ('I think I can learn more how [second year students] design,' R1), and how they work address design problems ('I think maybe it's a better way for us learn [...] to learn how [second year students] deal with different problems,' R1). The second 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)

and presentation ('all second years seem very articulate. They can speak in front of a group,' Jessica.R3). The role of second 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).

The positive value of mentorship is well established in the literature both within and outside of design education, 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 or direct) by the professor coming in opposition to the desire for more direct assistance by students. Student mentors were assigned for each project in the interaction design practice course, and the professor was available for additional consultation. Greg noted positively that their mentor 'was trying not to be too strong, you know, like say do this' (R1), 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). Mentors also served a 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), and others citing conflicting advice ('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). By the end of the semester, participants were generally more accepting, with Zhen reflecting: 'our mentor, helped us lot. And helped us trying to keep narrow down and to move forward' (R3).

The input from the professor, in particular the professor for the interaction design practice course, was seen as valuable by all of the study participants. The expertise and critique of that professor was seen as different in quality, as compared to student mentors. The professor intervened in groups where he noticed difficulties arising, helping them use 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; '[The professor] had an intervention with us, like look guys, you guys are doing it wrong,' Jonathan.R2) 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; 'we met [the professor] and he gave us some suggestions that […] if we can't move on, then we present nothing Thursday,' Xia.R1).

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. A course on visual literacy was being offered for the first time, alongside the interaction design practice course and an HCI readings course. The design course offered a primary design experience, with several group projects and an emphasis on developing patterns of design thinking. The HCI readings course used the structure of 'three waves' of HCI (Cockton, 2008) to talk about divisions of research from business application to multi-user systems to hedonic qualities of interaction. The visual literacy course 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 ('[the HCI readings] 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), immediate value for research ('before I read this paper [in the HCI readings course], I not think about search ubiquitous computing,' Zhen.R2), 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 [readings course professor] is talking about um emotions should be a priori to reason, I feel like the same way,' Jiao.R3). The contrast of individual and group assignments between the visual literacy and intensive design course was also important, both in feelings of success ('I feel—a lot more in control of the products for [the visual literacy professor's] class,' Jessica.R1), and the ability to apply visual knowledge to presentations ('I know, you can see the changes in our presentation,' Zhen.R2; '[the visual literacy course] has brought me a lot of value in um (.) thinking critically about the choices I make in the PowerPoint presentation,' Jonathan.R3).

Limitations of This Study

In this study, factors that were found to influence design thinking from a student perspective in a specific instantiation of design pedagogy were investigated. As such, none of these results should be seen as directly transferable or generalizable to other design programs, design 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 often 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 on-going effectiveness of the studio. In this study, a series of factors have been outlined 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 the studio signature pedagogy is implemented into additional disciplines, it is important to view the studio in a holistic way, and by extension, understand the design learning environment as a 'coherent system of activity' (Shaffer, 2007, p.100). 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.

While existing factors identified in the literature were found to be present in the context of this design program, the critical perspective of this study recontextualized these factors, along with the identification of new or underrepresented factors. Taking on the perspective of a student's experience of pedagogy foregrounds issues of uncertainty and ambiguity, highlighting the social interactions between fellow students, and the role of communication and individual effort in learning to think in a more designerly way. While many of the factors identified in the literature review, environmental, social, formative, and evaluative, are still important to consider, taking on a critical perspective allows for a more nuanced view of the formal pedagogy and the student's experience of that pedagogy. The majority of the new themes identified in this study stem from experience that expands beyond the formal classroom, or beyond the purview of a specific professor. It is this confluence of experience where personal experience and pedagogy meet that must be understood more deeply in order to conceptualize how student development occurs.

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comgray@indiana.edu