

Pedagogical Strategies for Reflection in Project-based HCI Education with End Users

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ABSTRACT

As HCI pedagogy research grows, so too does an emerging set of evidence-based teaching and curricular recommendations. Yet, few studies have implemented and examined these recommendations in the classroom. In this paper, we present a Research Through Design investigation of a studio-based HCI course, which was revised based on HCI education literature. Drawing on reflection surveys, video recordings of student-led user sessions, final project artifacts, and student interviews, we explore how students responded to key educational changes, the strategies that supported and hindered their reflective practices, and how reflection afforded new student insights. Our findings highlight the utility of video-based reflection exercises to support student learning in designing and running user sessions, the importance of multi-faceted reflection prompts, and how students noticed moments of inclusion and exclusion by attending to users' non-verbal cues. Additionally, we empirically demonstrate the importance of implementing and studying HCI education research recommendations in the classroom.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **Empirical studies in HCI**;

KEYWORDS

HCI education, participatory design, interaction design

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1 INTRODUCTION

As the field of HCI and interaction design matures, there have been increased efforts to actively reflect upon, investigate, and propose pedagogical approaches and curriculum [63, 81, 82]. For example, prior work recommends HCI/d curriculum that responds to the dynamics of socio-behavioral contexts [31], supports a multidisciplinary science [6], and bridges design philosophies and practice [35, 74]. While valuable for informing “best practices”, little work exists in actually studying these recommendations in the classroom—perhaps because HCI education research is still in its infancy [36, 72, 75]. Scholarship on the translation of research to HCI classroom practice presents an opportunity to: understand student learning experiences, support educators in making informed pedagogical choices, and explore how best practices must be adapted based on context.

Building on calls for more research contributions on HCI pedagogy [75], we present a Research through Design investigation [80] of a studio-based HCI course, which was revised based on HCI education recommendations in the literature [13, 51, 57] and investigate how these changes seemed to impact students' educational experience—with a specific focus on how students prepared for, learned from, and reflected upon their participatory design sessions. During the course, 42 graduate-level HCI students grouped into 12 teams worked to design an interactive digital game with a social impact component. To inform and test their prototypes, students engaged in two participatory design (PD) sessions with children using Cooperative Inquiry, a PD method supporting design partnerships [17, 78].

User studies, like PD methods, are critical to design practice but difficult to teach without experiential learning. To help students develop the skills necessary to plan, execute, and learn from user studies, we scaffolded their study plan preparation, provided and discussed curated video examples of participatory design sessions, and added reflection activities. Reflective practice, as fundamental to learning, can help designers make sense of the many complex, messy, and unstable situations they experience. Drawing on Senegers *et al.*'s [57], Roldan *et al.*'s [51], and Cook *et al.*'s [13] recommendations for incorporating reflection into HCI pedagogy, we

introduced written reflection activities at the beginning and middle of the quarter and, most critically, incorporated video recording, expert analysis, and discussion of student-led sessions with user. In this paper, we examine the impact of these revisions on the HCI student learning experience, including:

- RQ1: How did the educational experience of HCI students seem to be affected based on course revisions as suggested by previous literature?
- RQ2: What strategies seemed to support and/or hinder students' reflective practices?
- RQ3: Did students gain insights while being engaged in reflective practices in their HCI education? If so, what insights?

To address these questions, we draw on four sources of data, including: reflection surveys, video recordings of student-led PD sessions with children, artifacts from final project documentation, and semi-structured interviews with 20 students. Our findings suggest that our course revisions helped better prepare students for their user-study sessions, think through best- and worst-case scenarios, and identify opportunities for growth in their second session. We surface pedagogical characteristics that support and hinder students' reflective practices, including multi-faceted prompts, curated video clips, ongoing engagements as well as uncomfortableness of watching oneself, activity timing, and buy-in. Finally, we present insights that students gained in our course: attending to moments of inclusion/exclusion, attending to body language, navigating engagements with users, and naming future actions. Through these findings, we present a study about the design and implementation of reflective classroom techniques in an HCI studio-based course.

Our contributions to the HCI community are twofold. First, we incorporate educational recommendations from prior research into our classroom and analyze their impact on pedagogical outcomes. Through this contribution, we address a gap in the implementation of evidence-based pedagogy research in HCI education. Second, building upon previous recommendations in HCI [13, 51, 57], we call for the notion of “noticing” and “reviewing tape” for HCI education in a peer-led setting—such practices are common in the learning sciences [16], teacher education [18, 24, 25, 66], sports psychology [8, 34, 65], and healthcare [7, 14, 33], but uncommon in HCI pedagogy. Our findings extend the concept of noticing for HCI, as encompassing the ways in which designers observe important details in users' feedback and body language, interpret user input, and dynamically adapt during user sessions.

2 RELATED WORK

2.1 HCI Education

In 1992, the ACM SIGCHI Curriculum Development Group published the “Lime Green Report” outlining the ACM curricula for Human Computer Interaction [60]. The report proposed four courses for HCI oriented toward: technology, humans, practice, and research. Notably, the report also called for HCI to actively reflect on, study, and further develop its own curriculum. Since then, there have been only intermittent attempts to study HCI pedagogy [54] but recent developments are promising. From 2011-2014, ACM SIGCHI community members investigated the present and future of HCI education [9]. More recently, St-Cyr *et al.* formed a community of practice for HCI education [62], CHI 2019 introduced

a subcommittee on learning, education and families [83], and a working group was established to rethink the future of design education [82]. Furthermore, over the past two years the DIS community has increasingly embraced scholarship on HCI education [13, 46, 56, 71, 74, 75].

In the HCI education literature, prior work has explored how disciplinary perspectives [29, 75] and student experiences [13, 76] shape HCI pedagogy. For example, Watkins *et al.* call for design philosophies that support student industry trajectories [74] while Oguamanam *et al.* investigate how studio-based learning conflicts with cultural norms in computing [46]. Scholars also offer recommendations to support students' competencies [5, 26], tools to support educators [56, 71], and ways to expose students to authentic design settings [10, 36, 48]. Importantly, while scholarship has led to recommended guidelines for HCI educators, we could find no specific examples of follow-up work that integrates and studies these guidelines in the HCI classroom. One reason may be that most research on HCI education has taken place in the past five years [10, 46, 72, 75], which has provided fewer opportunities to further implement and study pedagogical recommendations. In contrast, in teacher education [18], it is common for researchers to implement and study research recommendations in their courses. In this paper, we apply an iterative, self-study approach to HCI education responding to Wilcox *et al.*'s [75] call for more concentrated research efforts to inform and shape the everchanging landscape of HCI design education.

2.2 Reflection in Education & HCI

Drawing on literature [13, 51, 57], we emphasized opportunities for student *reflection* in our course revisions. Reflective practice can be understood “*as the process of learning through and from experience toward gaining new insights of self and/or practice*” [20]. In education, a reflective approach is necessary for students to make sense of the many complex situations they experience. Importantly, students do not engage in reflection automatically, they need support to learn from the situational complexities they face [70]. Although definitions of reflection in education vary [40, 50], common attributes include surfacing unconscious aspects of previous experiences, thinking about the biases that drive one's actions, and formulating a plan for the future [13, 40, 50, 57]. In HCI, reflective design can support designers to surface assumptions embedded in their technologies [57]. Sengers *et al.*'s [57] work inspired other HCI researchers to further define [22] and explore reflective design for sustainability [3] and critical making [47]. In 2020, Roldan *et al.* [51] and Cook *et al.* [13] separately conducted investigations that concluded with similar reflection-oriented pedagogical recommendations. Roldan *et al.*'s [51] work extended Sengers' reflective design principles for HCI pedagogy while Cook *et al.*'s [13] work presented guidelines to support reflection on peer feedback. In this paper, we implement and study Roldan *et al.* [51], Cook *et al.* [13], and Sengers *et al.*'s [57] reflection guidelines in the HCI classroom.

2.3 Scaffolded Techniques and Tools to Support Reflection

Education scholars propose a range of techniques and tools to support teaching reflection, including weblogs [77], journals [39, 50],

and portfolios [61]. With the emergence of low-cost video equipment and the ability to easily capture, edit, replay, and critique interactions from a third-person perspective, video has been increasingly used to support learning, growth, and reflexive practices in teacher education [18, 24, 66], sports psychology [8, 34, 65] and healthcare [7, 14, 33]. In the context of training pre-service teachers, video enables educators to focus on their students in-the-moment while supporting post hoc review and reflection [24, 42, 66] and has been shown to shift teacher’s behaviors in the classroom [73]. In sports, video reduces reliance on memory, allows for rewinding and re-analyzing key moves, and supports understanding viewpoints for both athletes and coaches [8]. In healthcare, video is used to “feedback” curated aspects of a clinicians’ practice and thereby engender reflexivity, with the aim of improving practitioners’ ability to deal with problematic aspects of work [33].

While beneficial, using video requires equipment, training, and the time and expertise to clip appropriate video snippets that highlight “teachable” moments. Researchers describe curating video clips based on key moments [68] and the intentionality behind using video as a tool to promote future action for improvement [7, 27]. In practice, teachers record themselves delivering lessons and use video annotation tools to document their observations, while external educators (*e.g.*, teacher mentors) scaffold their attention to specific aspects of their instruction [11]. Similarly, dancers video record their routines, select video fragments of their movements, upload clips online, respond to guided prompts from their dance instructors, and receive feedback from peers on their clips; this in turn supports dancers in developing a more realistic view of their dance experience [38]. In sports, athletes watch video clips of their performance curated by consultants to show technique, positioning, or team plays [34].

Common across contexts is the use of video in group settings to see peers’ practices [7, 8, 14, 18], the inclusion of scaffolds such as prompts to encourage discourse [7, 66], and the opportunity to interpret the same moment from multiple perspectives [7, 44, 64, 68]. van Es and Sherin [18] highlight that video is only a tool for learning, and that pedagogical scaffolds in contexts are necessary to leverage what video has to offer [37]. As much as video has been used in other contexts, video is rarely used as a tool to support student and educator reflection in HCI pedagogy. Investigations that do involve video ask students to submit project videos as a form of assessment [69] or educators to video record their lectures to support active learning [32]. Informed by research from HCI education, reflective practice, and techniques and tools to support reflection, we made key changes to our HCI course that included an intentional focus on scaffolding student reflection. We examine the role that scaffolded reflection strategies on video plays in how HCI students make sense of their engagements when designing with children in their studio course.

3 METHODS

We examine a 10-week master’s level HCI+design studio course taught between January and March 2020. During the course, 42 HCI students grouped into 12 teams worked to design an interactive digital game with a social impact component. To inform and test their prototypes, students engaged in two PD sessions with children.

We video recorded all PD sessions and annotated them for analysis. Informed by prior work [13, 51, 57], we asked students to engage in reflective exercises. After the course ended, we conducted 20 semi-structured interviews with students about their experiences and collected artifacts from four teams. Through these methods, we gained unique insights that foregrounded students’ perspectives about our process of implementing key course components and how those changes influenced student insights about working with users.

We take a design inquiry approach [80]. Research through Design [79, 80], a well-established method in HCI, offers an approach to conduct scholarly research on implementing recommendations into HCI education by employing methods, practices, and processes of design practice. Zimmerman *et al.* [80] draw on Frayling’s [23] concept of Research through Design to describe the process by which design researchers generate knowledge intended to transform the world from current state to preferred state. In our work, we saw an opportunity for more evidence-based practices in HCI—reflection in particular. Therefore, we implemented five key course revisions in our classroom as informed by prior HCI and education literature and observed the value of supporting design students to notice in their user studies. Our investigation has undergone an active process of reframing how to support design students in their engagements with end-users during participatory design sessions. This paper details our inquiry into how to support students in conducting user studies and how to scaffold their reflection on engagements with end-users.

3.1 Context

Course. The HCI+design course is required curriculum for an interdisciplinary design master’s program at a large research university and introduces prototyping and evaluation methods via project-based learning in a studio environment. Over the 10-week quarter (Figure 1), HCI students worked in teams of four to design a socially relevant, multi-player video game for children with a custom, tangible input controller made from Arduino. We intentionally designed course assignments, lectures, and studio time to scaffold students through the design process. In the course, students learn prototyping theory, techniques, and tools in the human-centered design process, including hardware prototyping, digital fabrication, and lo-fi form crafting. Specifically, the stated learning goals of the course were: (1) Students will engage in the human-centered design process from ideation to lo-fidelity implementation to building and evaluating an embodied interactive prototype; (2) Students will develop, learn, and use varying physical prototyping techniques; and (3) Students will learn techniques to seek, synthesize, and incorporate user input and accommodate feedback from multiple stakeholders (including users, guest critics, and instructors).

Participatory Design Team. For the PD sessions, we paired with KidsTeam UW an intergenerational participatory design group of children and adults. Prior to the COVID-19 pandemic, KidsTeam UW participants met twice-a-week afterschool on a university campus to design new technologies for children, with children. KidsTeam UW follows the Cooperative Inquiry method [17] where children are positioned as design partners through a dynamic process which shifts between balanced and unbalanced interactions

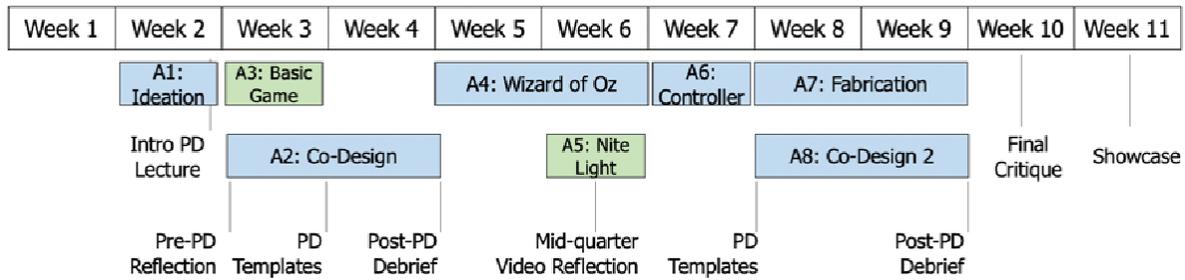


Figure 1: Course Timeline. Blue boxes are team assignments while green are individual or paired assignments.



Figure 2: Images from PD sessions

[78]. 10 children (ages 7–11) and 8 adult researchers from KidsTeam UW worked with the HCI students.

Participatory Design Sessions. The HCI/d students engaged in a total of two, 90-minute PD sessions with children. Sessions began with snack and circle time (30-minutes) where everyone shared their name and answered the question of the day. During design time (45-minutes total, 15-minute rotations), students engaged the children in round-robin design activities (Figure 2). Student teams were given autonomy to use their design time as desired and adults took notes of key takeaways. After design time, everyone reconvened and shared their experiences with each station. We video recorded, time-stamped, and annotated all eight PD sessions for key moments of engagements between students and children.

3.2 Key Changes

Our investigation builds on recent research that supports reflection in HCI pedagogy [13, 51, 57]. In Table 1, we provide an overview of the changes made from our Year 1 (2019) course offering described in [51] to our Year 2 (2020, pre-COVID-19) course offering. For more details on the 2019 course, see Roldan *et al.* [51]. We made multiple changes from our Year 1 course [51] to our Year 2 course, including: expanded lecture on PD with children, the use of reflection exercises and curated video clips, example PD session templates, and post-PD session debriefs to support the course learning goals. We do not intend to make explicit connections between the changes made and the outcomes we present in the findings because there were different students in each year's course and different contextual influences. The 2019 and 2020 course had the same lead instructor who is also a co-author of this paper. Below, we describe key changes.

Introductory PD Lecture. In Week 2 of the 2020 course, we gave students a lecture on PD with children in KidsTeam UW, offering an introduction to Cooperative Inquiry [17] and insights from previous research [51]. We included video clips from prior participatory design sessions that showed both successful and challenging instances of students and children designing together. We shared an overview of who would be in the room during the sessions (children and facilitators) and offered insights on who the children were (their motivation to participate). We also handed out quotes of advice from students who had previously worked with KidsTeam UW children. The goal of this lecture was to provide students with strategies for engaging in the human-centered design process (course learning goal 1) including building rapport, communicating with the child designers, and using their design time efficiently (*e.g.*, moving between methods, alternating between materials, attending to the child to adult ratio, and being flexible).

Pre-PD Reflection. Before their respective sessions, we asked each design student team to fill out a pre-session reflection. Via Google forms, we asked students what they were most excited about for their first session, what strengths they had for working with children, what artifacts they planned to bring to the sessions, how their team planned to work through unexpected challenges, and what concerns they had going into their sessions. In alignment with the third course learning goal of students learning techniques to seek user input and accommodate feedback from multiple stakeholders, the rationale of the pre-reflection questions was to scaffold students to think in more detail about how they would approach PD and to think about contingencies and to gather information on them through processes as they approached their design sessions.

PD Templates. Prior to each PD session, students filled out a detailed session template with their goals, plans for achieving those goals, and materials they would bring (Figure 3). The template also

Table 1: The curricular and process changes between our 2019 and 2020 course

Course Component	2019	2020	Rationale
Introductory PD lecture	A presentation by PD facilitator	Augmented with historical video clips	Show students examples of prior student-user interactions ranging from successful to challenging
Pre-PD session reflection	N/A	Reflection prompts to brainstorming strategies	Support HCI students in considering and articulating their plans for Session 1
Pre-PD session templates	N/A	Session templates: goals, materials, time	Support HCI students to thinking through their research goals and how to meet them
Post-PD session debrief	Student-led debriefs	15-minute debrief session with facilitator	Support HCI students unpack the interactions and name top-line takeaways
Mid-quarter video clip + reflections	N/A	Curated Session 1 clips and reflection prompts	Support students to remember, notice, and reflect on what they learned from Session 1
Project goal	Client-based	Social impact based	Support HCI student choice and bring video game focus to designs
Session timing	Weeks: 2,3 and 8,9	Weeks: 2,3 and 7,8	Allow more time for changes to be implemented into students' final designs

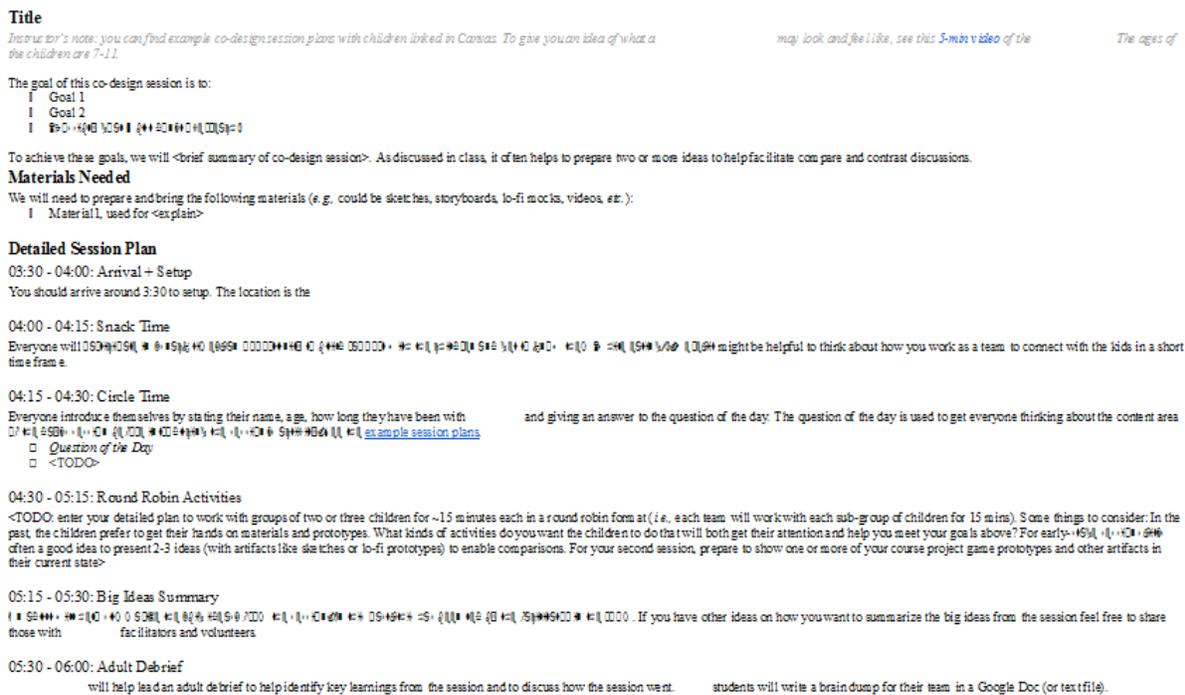


Figure 3: PD Templates. See the supplementary materials for template details.

asked them to break down how they would use their time and what they would do for their round robin activities to support students in developing techniques to seek user input for their designs. The templates were intended to help students plan how they were going to structure their session to meet their goals. We added these templates to our course this year because we found that without this scaffold (in previous years) students did not fully think through the entire process of how their design sessions would help them meet their design objectives for their game.

Post-PD Session Debrief. Following each PD session, the lead author led a 15-minute reflective debrief exercise which we also video recorded. The goals of the debriefs were to help students unpack their PD session and to collectively make sense of their takeaways from the session to synthesize and brainstorm how the user input gained would inform their final design. We followed a semi-structured protocol that asked: How did it go? What surprised you? What was expected? What was challenging? What were some moments of pride?

Table 2: Participant Overview. *All names are pseudonyms. Team 2 and 5 did not attend Session 2 due to COVID-19.

Team & Session	Project Prototype Ideas	P#	Participant	Background, prior design experience
Team 1 (1 & 8)	S1: Feather blowing	13	Bailey	Computer science, web design
	Boat steering (counting fish)	3	Caelen	Product, graphic, motion, and production design
	Constellation lighting	8	Hadley	Industrial design, prospective UX designer in IOT
	S8: Tree planting	14	Vega	Product design, hand letterer
Team 2 (1)	S1: Cleaning ocean garbage (Wheel navigating and net throwing)	16	Avery	Sound design, accessibility researcher
		12	Wase	Environmental, exhibition design, architecture
		15	Nell	Graphic design, marketing, and user researcher
		11	Aria	Design research, accessibility researcher
Team 4 (2 & 5)	S2: Designing koala habitat	20	Mason	Interactive media arts, multidisciplinary designer
	S5: Submarine			
Team 5 (2)	S2: Reaching stars	9	Niki	Industrial design, wearable technology, sports
Team 6 (2 & 8)	S2: Racing, alien laser	6	Nao	Brand design, freelance web design
	S8: Alien trash collector			
Team 8 (3 & 7)	S3: TikTok & Tetris	5	Yan	Psychology; IT consultant and music enthusiast
	S7: Laser reflection	7	Hunter	Math and Visual arts; product designer (3+ years)
Team 10 (4 & 5)	S4: Cat puzzle, wizard spells	2	Max	Art theory, digital humanities, inclusive tech
	S5: Cat in the forest	1	Wren	Computer science, studio arts, cognitive science
Team 11 (4 & 7)	S4: Embodying shapes	4	Ollie	Computer science, editorial design; visual design
	S7: Catching nutrients using your body to navigate controller	10	Randi	Production designer
Team 12 (4 & 6)	S4: Blowing bubbles	18	Ray	History, UX designer
	S6: Helping endangered animals	17	Kali	Management science, UX researcher
		19	Willow	Architecture, healthcare

Mid-quarter Video Clip Showing + Reflections. Informed by literature on the use of video to support reflection [7, 18, 34, 51], between Session 1 and Session 2 we sent students curated video clips from their first session. Via Google Forms survey, we sent teams two curated video clips from their session and we asked them view both but pick one to reflect on. Each team's clips were curated by researcher that met the selection criteria: multiple HCI students were notably engaged with children and two researchers decided there were multiple interpretations to the engagements. The burden of curating clips was solely on the researchers. After watching the videos privately, we asked students to reflect on observed behaviors, their interactions with the children, and to consider what they would change for Session 2 via written prompts.

We expected that an outcome from this course component would be mutually beneficial to students, educators, and researchers. After watching their videos and answering reflective prompts, we expected students would compare their goals and plans for the session with the reality of what played out in the video data. In making this explicit comparison, we hoped students could reflect on the need for flexibility in the design process as they learned techniques and strategies to engage user input for their embodied interactive prototype. From the perspective of their future self as a professional designer, we asked them what they felt was successful and what was challenging from the interactions in the clip. In the form, we also asked students to describe to us what they observed was happening during the clip and to rate how satisfied they were as a team with the interactions they had watched. This course component was a chance to compare how students saw themselves in the video with how educators and researchers interpreted the clips.

3.3 Interviews and Material Artifacts

After the course ended, we conducted hour-long semi-structured video interviews with 20 (of 42) students who received a \$25 gift card for their time. We asked participants (Table 2) about their experiences in the course and with the PD sessions. Similar to our mid-quarter reflection, we showed them a clip from Session 2 that showcased a notable moment between them and a child. In contrast to our mid-quarter reflection, where we were focused on the team's engagements, these clips focused on engagements that involved the interviewee. Following interviews, we collected and analyzed design documentation from four (of ten) student teams.

3.4 Data Analysis

We followed qualitative research approaches aligned with interpretivist lines of inquiry [12, 15, 53, 84]; where knowledge is seen as interactively constructed between researchers and participants [28]. Our dataset included student responses to two reflection surveys, video recordings of eight student-led PD sessions, artifacts from project documentation, and professional transcripts of semi-structured interviews with 20 students. These four data sources provided a rich and thick description of the students' experiences and allowed for triangulation [58]. The lead author also kept reflective and analytical memos throughout the research process [45]. Six researchers independently open-coded the reflections (N=24), the video annotations (N=8, 720 minutes), the video interview transcripts (N=20), and the design artifacts (N=4).

For three months, the six researchers engaged in weekly peer debriefing sessions following each open coding of the data. Iteratively, we developed a codebook with 10 high-level codes and

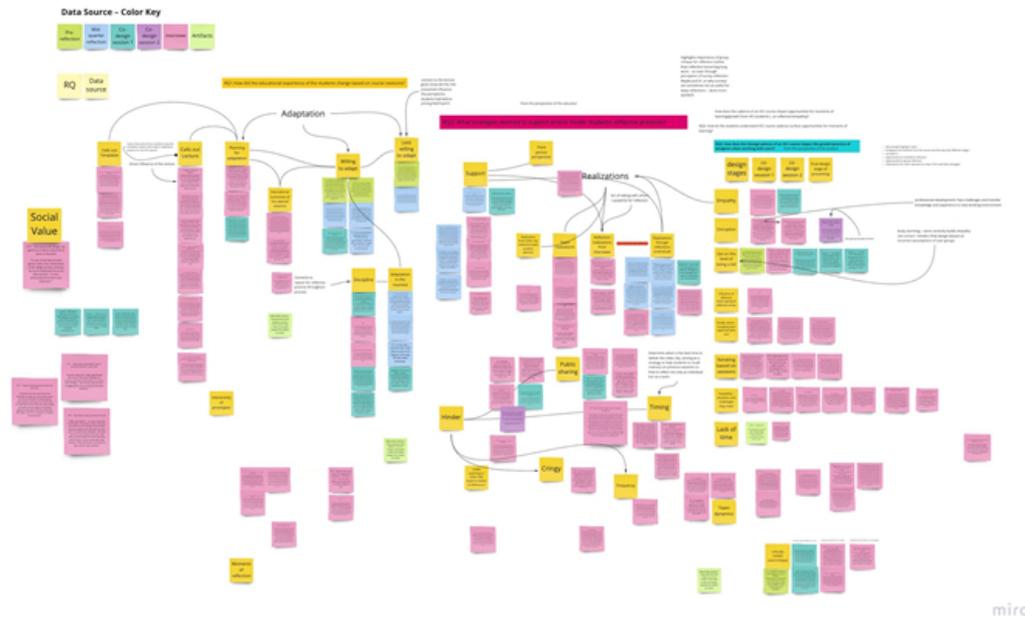


Figure 4: Snapshot of data analysis process. See the supplementary materials for a larger, more readable version of this Miro board.

122 sub-codes. At this stage, our high-level codes included course cadence, key changes, adaptation, and expectations. After open coding, each researcher wrote analytical memos of the high-level codes, which were discussed during weekly meetings. Informed by ongoing engagement with our related work, these analytical memos helped us conduct axial coding between core themes. Following the identification of core themes, we used a visualization software [85] to map our codes and data (Figure 4) and arrived at our findings. Following standard practices of qualitative research [4, 43], we do not report exact participant counts of each theme for two reasons: (1) our semi-structured interview approach meant questions were not asked in the exact same manner to every interview participant and (2) we do not aim to generalize from a small set of data points.

Positionality Statement. The researchers on this project are students and educators who have previous experience conducting research in a similar study, thus allowing for discussions which connected past experiences and current research. These discussions surfaced subjective perspectives that required validation through analyses of thick description data [58]. We also draw on the course instructor’s knowledge who is a co-author and taught both in 2019 and 2020. Some researchers are HCI students and volunteers Kid’sTeam UW and their perspectives are informed by their personal experiences. As a research team, we have built trust with each other through previous collaborations. These perspectives and experiences influenced our analysis [52].

4 FINDINGS

In this section, we present students’ educational experience from our course changes as informed by HCI education [13, 51, 57], the pedagogical strategies that supported and hindered students’

reflective practices, and the insights students gained as a result of being engaged in reflective practices as part of their studio-based HCI course.

4.1 Students’ Educational Experience from Implementation of Course Revisions

We describe how students experienced our key educational changes from Year 1 (2019) to Year 2 (2020): introductory PD lecture, PD templates, pre-PD session reflections, post-PD session debriefs, and mid-quarter video clips and reflections. For each course revision, we provide an overview, a synthesis of students’ educational experience and key takeaways.

Introductory PD Lecture. We extended our introductory PD lecture in Year 2 to include curated video clips from past PD sessions and a handout of “recommendations” from previous students. Year 2 students stated that the lecture provided insights into the complexity of working with children designers, set expectations for session dynamics, and provided pragmatic strategies for working with children. For example, Niki suggested not just monitoring user behavior but asking them “*why are we doing that?*” Bailey said watching the video clips, “*was helpful for my team to get on the same page of what to expect*” and that the lecture directly informed their session planning. Despite the lecture, after their first session students commented on the children’s energy, experimental nature, and “mis-use” of prototypes: in Session 1, for example, a child put a plastic feather in their mouth. In short, the lecture scaffolded students into a previously unknown design context, provided real-life examples of successful and challenging interactions between designers and users, and helped reduce anxiety about “perfectionism”

and “control.” Students recommended showing user-session video clips to future courses.

PD Templates. In Year 2, we provided session plan templates and protocol examples to student teams, which were not provided in Year 1. In general, students felt that the templates helped them think through their session, “know how everything was going to work out” (Nao), set concrete goals, and establish a plan for meeting those goals. For instance, Hunter said, “It’s directly related to what we’re going to do during the [participatory design] to understand what we’re going to achieve, and how are we going to use different activity question(s) to achieve that goal.” The templates included timings both to help structure student’s time allocations and to help highlight the rapidity of the session. In contrast to Year 1, the teaching team and PD facilitators felt that the teams were better prepared, particularly with regards to having age-appropriate design activities, rapport building, and the variety of physical materials for each session. While students appreciated the scaffolds and the example session plans, they felt that the templates were less useful for their second sessions. As Vega described, “it was not like doing these different activities or asking these different questions that could help us in narrowing down or anything. . . .” Vega’s quote also helps emphasize an additional concern: how to analyze the rich session data to inform prototypes and make design decisions—an opportunity for further scaffolding focused on analysis.

Pre-PD Session Reflection. In Year 2, we added pre-session reflection exercises, which asked student teams to think about, discuss, and report on what they were excited about, their concerns and team strengths, how they planned to build rapport, and work through unexpected behaviors. In their reflective writings, students expressed excitement about creating an interactive prototype and learning from the children but also shared concerns about the understandability of their games, session length, keeping the children engaged and safe, and anxiety about how to interact with them as designer partners. Team 8 said, “We have prepared easy to understand and short summaries of each game; in case if the children get confused with our games. We also plan to demonstrate...” Students listed multiple session-handling strategies including being approachable, patient, and respectful as well as designating clear roles for the adult and children designers. Team 3 wrote, “. . . to engage with them early equally. By this, we mean getting to them very early during the [participatory design] sessions, as well as treating the kids as intelligent human beings.” When discussing their strengths, teams identified their complementary personalities, prior experience with usability testing and facilitating design sessions, and their flexible approach. In Year 2, we observed how having students brainstorm a list of strategies and assets they could rely on meant they had a repertoire to pick from while in their sessions. In sum, the pre-reflection exercise helped students envision their session, think about “best” and “worst” case scenarios, identify key team strengths, and articulate a plan for working through unexpected behaviors.

Post-PD Session Debriefs. In Year 2, we added debrief sessions which enabled students to reflect on and discuss surprises, challenges, and key findings. Because they occurred immediately after the PD session, students were both exhausted and energized and used the debriefs to work through and articulate their thoughts, collectively make sense of particular moments, and share strategies,

concerns, and insights. Students also appreciated hearing from the lead author about her observations, as an expert. After their first session, students synthesized features that engaged the children (e.g., healthy competition), brainstormed improvements, and unpacked strategies for their second session. Max said, “In the first session, we couldn’t always keep it in focus. So, by externalizing that in the debrief, we knew we were going to have to set up our research session differently next time.” After the second PD session, student commented on the durability of their prototypes and the changes they would have to make before the final design. Students learned from each other and were able to see multiple interpretations of the design session. Hunter noted, “Knowing what is happening to their team can also give us some insights.” Interestingly, we learned this year student teams still held a second round of debriefs without the facilitator to synthesize key insights for next steps.

Mid-quarter Video Clip Showing + Reflections. In Year 1, we showed students PD session video clips after the course’s completion as part of our research study. In Year 2, we made these “video reviews” a key part of the curriculum, following Roldan *et al.*’s recommendations [51]. When comparing their session goals with the video, Year 2 students noted that they were successful in establishing a relationship with the children, gathering exploratory information about their interests, and observing their interactions. Team 3 wrote, “. . .our biggest success was engaging with the kids in a way that made them feel comfortable and able to express themselves openly.” Students felt less successful in predicting how children would use their prototypes and found that the children struggled with game narratives and mechanics. For example, Team 9 said, “. . .a lot of game mechanics did not play out the way we wanted it to be. For example, the spinning bamboo copter didn’t have anything to do with the game and the spinning action was not intuitive at all.” Students said it was challenging to keep conversations going and to keep children’s attention when giving game instructions. Team 11 wrote, “The challenge for me is learning how to work with a sensitive and unpredictable user group, being flexible with the plan, and responding quickly to the different conditions.” In response to what they would change, students said they would spend less time giving instructions and simply observe, would change their activities to gather more targeted input, or would respond dynamically. By preparing and showing key PD session video clips to teams, students had an opportunity to see their interactions from the “third person”, talk about and replay key moments, and identify opportunities for improvements for their second session. Team 2 wrote, “our protocol was designed to treat all the kids the same, but in reality, we need to adjust what type of questions we ask, and our voice and tone based on who we are talking to.”

4.2 Pedagogical Characteristics that Supported/Hindered Students’ Reflective Practice

Next, we outline the pedagogical characteristics that supported and hindered students’ reflective practices from our revisions, including multi-faceted reflection prompts, curated video clips, ongoing engagements as well as uncomfortableness of watching oneself, activity timing, and the lack of buy-in.

4.2.1 Pedagogical Characteristics that Supported Reflection. Multi-faceted Use of Reflection Prompts. We presented students with holistic multi-faceted reflection prompts, including within-team reflections (watching videos, writing pre- and mid-reflections), cross-team reflections (conversational debriefs), and individual reflections (writing pre- and mid-reflections). We found that this avoided repetitiveness and offered different ways for students to relay their thoughts. For instance, Wase noted: “There are just so many things that you could miss in your notes, especially with this kind of designs [PD]. You have to see what their actions are. . . especially putting it alongside with the reflection, like watching it [the clips] and writing stuff after to reflect upon it.” Wase explained how having multiple ways to reflect supported sense-making.

Curated Video Clips. We found that the curated video clips supported students’ reflective practices by considering multiple points of view from students, instructors, and researchers. For students, the curated clips provided a structure for what they should focus their attention to and surfaced nuanced interactions (that might go unperceived) for reflection. Mason said, “If you ask me to think about our design process out of my head, I can only think of the moments where I struggled the most. . .” When watching the clips in a group setting, the teams saw their own behaviors and collectively interpreted the clip which in turn allowed them to generate critiques and compliments on individuals or groups’ behaviors. For instructors, the clips allowed us to work closely with the HCI students, slow down, and carefully review their sessions for subtle cues of their interactions.

Ongoing Engagements of Reflection Prompts. We consistently scattered multiple reflection points throughout the course rather than one larger activity. As a result, students made reflection a part of their design process. Max said the prompts “. . . sort of force people to be like introspective about how they communicate with our [design partners] and also the other KidsTeam UW facilitators”. Compared to Year 1, students took a positive attitude towards children’s distraction as a sign of needing to try a new strategy. Randi noted, “I think just leveling that expectation of they [the children] are not going to design this thing for you. it’s more like reading between the lines and just trying to understand where they’re coming from.” Furthermore, persistent reflection prompts allowed students to not only reflect on their user engagements with users but also how they engaged as a team.

4.2.2 Pedagogical Characteristics that Hindered Reflection. Uncomfortableness of Watching Oneself. Students commented on the uncomfortableness of watching themselves on video. Yan stated being emotionally disrupted but finding the video clips helpful, “Even though it was cringy being watched, then we realized some things that we were trying to pay attention in the second session.” On the other hand, Hadley said they enjoyed watching the clips with her team, “We had lots of fun looking through that. Super embarrassing. . . Then we all sat down together and watched that video, and we all had this, oh sh**, moment. . . it really grounded us in okay, what do we need moving forward?” While it is not a surprise that students had uncomfortable moments watching themselves, we need to consider ways to be respectful and provide a psychological safe place for reflection and critique.

Timing of Reflection Prompts. Students spoke to the importance of when we prompted the reflections. Some students preferred to have video clips sent after some time had passed from their session while others preferred to see them right after. Nao said, “I feel like if we had to do that just before our second session, it might have been more useful, because then I would have just done that activity and remembered what we wrote.” Given the conflicting opinions about the timing, it is important to make reflection due dates variable and aspire to a faster turnaround of curating clips for students to watch when they think it is most valuable to them.

Buy-in. Buy-in relates to the students’ perceived value of course activities and is important for sustainable implementation of reflective practices. Students said some of the exercises felt like “busy work.” Others did not see the connection between the activities and the course objectives. Hunter stated, “that clip might help us to have better behavior for the second [participatory design] session. But I feel like the video wouldn’t impact our big picture.” Recognizing that the course had many deliverables and moving components, we acknowledged how the addition of reflection activities could be taken as another assignment as opposed to a valuable engagement.

4.3 Student Insights from Being Engaged in Reflective Practices as Part of their HCI Curriculum

We present insights that students gained as part of our reflective exercises: attending to moments of inclusion and exclusion, attending to body language, navigating engagements with users, and naming future actions.

Attending to Moments of Inclusion/Exclusion. After watching their first PD session video clips, student teams commented on opportunities to actively keep their users focused and create opportunities to involve all children during their session. In watching their videos (Figure 5), student teams noticed that most of their games were 1- or 2-player and often that meant “having one person do the activity and the others watch” (T1). Team 5 wrote, “In the next session, we would like to think of a couple ways the kids can be involved while not currently playing. . . For example, we could have the children not playing help the kids who are with the strategy to get through the levels, or they can help remind them of rules. . .” Here, the team noticed a lack of engagement from all the children and proposed actions to keep the children’s attention. In their final artifacts, Team 8 described how they changed their game design after noticing children were being excluded by the two-person feature.

Attending to Body Language. When watching their video clips, students commented on opportunities to interpret non-verbal cues from users and to improve their body language (Figure 6), whereas in Year 1 they focused more on the chaotic nature of the sessions. Nell wrote, “not every single utterance from a participant is valuable. . . While it’s important to not treat sessions like interrogations, I think it’s important to note these dubious moments and use them to better understand your participants versus taking their word as gold and designing something they asked for verbatim.” After their first session, Nell reflected on the importance of knowing users versus taking users’ words verbatim. In our video observations, we noted an instance during the second PD session



Figure 5: Moments of Exclusion - Session 3 (left), Inclusion - Session 4 (middle), Exclusion/Inclusion - Session 1(right)

Successful:



T2 starting their activities with a sitting check-in

T3 letting the children figure out the game

T4 playing with the game with the children

T5 convincing a child to wait their turn using jokes

T6 designating roles among team members

Challenging:



T2 asking the children to stay in front of the prototype

T4 trying to give instructions while children start playing

T6 closing the laptop and asking the child to re-focus

T8 reacting to children mis-using the game materials

T12 helping a child, while he says "it is difficult to balance"

Figure 6: Key moments from curated video clips that were sent to students. For larger images, see the supplementary materials.

when a child said he did not like the game and a student responded, "but you've played for the third time, what does it mean?" Students also noticed their body positioning and intentionally shifted themselves to be at eye-level with the users. Randi said, "I think later a few minutes down the road or even before maybe, like looking at this, I'm seeing my body language was very authoritative." Ollie extended this observation to note the ways video helped them attend to micro-movements, "It also showed how they just in general interact. Like sometimes they sit on the floor. So, this is why it was helpful, because during the session you just focus trying to control everything, and you don't notice all those details." Here, we argue that our findings emphasize what other contexts have seen in the use of video showings to become "a way of saying the unsayable" [7, 41] but for HCI. Attending to body language is supported by the video visualization which enlarges sociocultural practices [7] that might previously be unnoticed. In this way, for our students, video clips became a way to foreground background aspects of activity occurring during their design sessions.

Navigating Engagements with Users. Students also reflected on two strategies that they found were successful in their engagements with users: being eye-level with users and investing into relationship building. Caelen reflected on the value of being at eye-level with children to mitigate power dynamics. They said, "I think I tried at times, to get more down on their level to talk to them, to be able to look at them, but it's hard because they're so fast moving." In their mid-quarter reflection, Team 10 wrote, "A tactic that was successful was talking to kids in a personable manner where there is a back in forth conversation of sharing experience.

Kids specifically like to hear how they relate to you and it helps them build on the conversation."

We found that during the sessions, students were intentional and showed genuine interest in getting to know the children. During snack time, students actively put themselves out there and introduced themselves to the children. Students also incorporated fun tools for children to play with like a silly hat, bubbles, or wands to both generate user input for their digital games and allow for whimsical connections. In our Session 6 video annotation we wrote, "The two adults convey moments when they realize something about her drawing, and both show genuine interest in learning about [child]'s picture. After asking several questions, one of the adults adds to the drawing to fit with [the child]'s story." Hunter also commented on the role of the video clips to show both children's and adult's reactions, ". . . it's kind of a reminder for us of what is happening during the session and kind of showing us not only how kids react to our game, it also reminds us how we reacted to the kids."

We observed students name their learnings and shift their initial perception of the user group as a homogenous group of children to recognizing every child was unique. Compared to Year 1, where students named perceptions of children, this year design students articulated the ways in which their perceptions changed over time. Reflecting on a moment when their team brought a wizard of oz prototype that the children knew was not real, Nao articulated her learning that the children were much smarter than expected, "I feel like that was all our bad, because like I think we really thought the kids might be really stupid or something. . ."

Naming Future Actions. Beyond remembering their interactions and noticing key engagements with users, students commented on how our reflective strategies helped them become better designers. Max said, “I think it is kind of funny to watch yourself retrospectively, and then you can identify, wow, I probably could have done this differently.” Wase named explicit actions for their future career as a designer to build rapport with users, “I would perhaps include an icebreaker game that can stimulate some creativity in them...”. Max said, “The clip shows that I expected more answers from the participants, and it’s obvious (to me, at least) that I ad-libbed my later questions. . . In the future, I should come prepared with a research activity in the event I am dealing with a participant(s) who may not have much to say in order to elicit conversation.” T5 drew connections between their engagement with children in this course and their future engagement with other vulnerable populations, they wrote, “I notice that I was watching a lot in this clip. . . this relates to the future of my career in trying to understand how to get the most out of time designing/researching with children or another hard to reach group.” Across their reflections, we saw students translate their learnings into their next PD session and to their future as designers.

5 DISCUSSION

Prior work in HCI education recommends more opportunities for students to reflect [51, 57]. Overall, our findings suggest that revisions in our HCI pedagogy supported multiple ways for HCI students to reflect during user sessions and to name actionable ways to improve on their engagements in the future. We offer pedagogical characteristics that support and hinder students’ reflective practices, including multi-faceted prompts, curated video clips, ongoing engagements as well as uncomfortableness of watching oneself, activity timing, and the lack of buy-in. Our work demonstrates how, through scaffolded reflection, HCI students can attend to moments of inclusion and exclusion, attend to body language, navigate engagements with users, and name future actions. We propose noticing as an important practice for design students to develop when engaging with others in user studies and highlight opportunities for future research to study how to support noticing for students in the classroom. Our findings extend the concept of noticing for HCI, as encompassing the ways in which designers observe important details in users’ feedback and body language, interpret user input, and dynamically adapt during user sessions. Below, we discuss opportunities in HCI education to develop scaffolds for noticing, pedagogical implications for training reflexive design students, and design recommendations for advancing reflective HCI pedagogy.

5.1 Scaffolding Noticing for HCI

Reflecting on engagements with end-users in authentic design settings is complex. In user studies, designers must be mindful of contextual cues, user behaviors and interactions, and their own self (e.g., affect, emotion, body language, bias, gestures) to support positive engagements. We cannot ask students to simply pay attention to moments occurring during their sessions. Just like teachers in education and athletes in sports, design students need *scaffolds* to know what to look for in the context of user studies and *practice*

looking for those interactions. In this paper, we offer insights into how we translated prior research recommendations to design new course components that helped students engage in reflective practices. By supporting students to review their engagements with users by leveraging video and providing tools for students to unpack what they noticed, our investigation shifts how HCI education can scaffold noticing and reflection during complex user sessions [79].

The Process of Noticing. Reflection in CHI relates closely to the concept of noticing [24, 25, 59, 67]. While noticing is new to HCI, the connection between noticing and reflection has existed since the 1960s [59]. In teacher education programs, educators teach students how to look back on what happens in the classroom, think critically about previous interactions, and then translate their learnings to the next time they are in the classroom and have to make quick decisions [19, 59, 67]. Noticing occurs in the moment. Expert teachers can recognize, react, and act on complex stimuli automatically [59]. Prior work offers an iterative model of teacher noticing in the context of a classroom where a teacher may: be bombarded with sensory details, attend to elements of the sensory data as the noticed thing, interpret, makes sense of, and reason about the noticed thing and then take action based on the noticed thing [59]. Similarly, in sports, coaches replay clipped moments from games to help athletes attend to their body positioning and make changes to their plays [34]. In these settings, sensory information passes fast, decisions need to be made quickly, and teachers and athletes must prepare for next time they are in that context. Sports and teacher education settings are analogous to user studies where multiple sensory inputs to reflect are present.

While the role of a teacher managing a classroom and a designer managing a user session can be similar, designers need to be attuned to different things such as usability problems, design suggestions and methods to solicit actionable feedback. In contrast to existing literature on noticing, our findings are situated within the context of HCI where design students must learn to engage in the human-centered design process, move an idea from low-fidelity mockups to a physical interactive prototype, and incorporate user input throughout. By adapting existing strategies for noticing, we can support students in learning how to conduct and learn from their user sessions. For example, in Seidel *et al.* [55] the use of video clips helped preservice teachers observe how expert teachers facilitated student group work, posed questions, and gave feedback in the classroom. In contrast, in our investigation, video clips helped design students observe how they implemented their study protocol and made the necessary adjustments for their second design session to elicit the desired user input.

The Process of Translational Work. A core contribution of our work is translating insights from teacher education on noticing and reflection in pedagogy—particularly how educators learn to pick up subtle cues of their instruction and student engagement—to HCI pedagogy where similarly designers must learn to notice the nuanced moment-to-moment interactions with users. The translation from teacher pedagogical reflection to HCI education is not a simple task. Most HCI educators have been trained in engineering and design programs and have not been exposed to teacher literature. Therefore, this paper connects existing research in other disciplines to HCI and provides empirical evidence of the strategies

that support and hinder students' reflective and noticing practices throughout their design process when working with users. Our contribution is a novel integration of theories on noticing and reflection with the technology affordances of video in the context of a studio-based HCI classroom [80].

Our design inquiry has broadly explored involving end-users in HCI classrooms and this paper specifically names reflective strategies to support students during user studies. From our 2019 course offering [51], we learned that reflection could support students in conducting user sessions such as participatory design sessions. Thus, we revised our 2020 course with the intention of scaffolding reflection for students. By implementing and studying our changes to the course, we became aware of the value of noticing to help designers make in the moment decisions through an ongoing process of recognizing, reacting to, and acting on complex user interactions. Our contribution is valuable given the prominent role of user studies in HCI practice, the complexity of stimuli present during user studies, and the opportunity we present to support students in learning how to reflect on their sessions through video-based reflection.

In this paper, we shed light on the process of adapting research in teacher education to HCI practice [30, 79, 80]. This work has brought together an interdisciplinary team of researchers, educators, and PD facilitators to implement and study best practices in the HCI classroom. The translational process has involved negotiations to ensure added course components prioritized students' educational experiences. Future work might explore how framing classroom interactions as design practice creates opportunities for HCI pedagogy. This framing surfaces opportunities for doing user testing with students, seeing curriculum design as iterative, and innovating on the design of curricular activities. We see potential in the HCI classroom as a design site to explore wicked problems with a range of stakeholders through the integration of true knowledge (*e.g.*, design skills and techniques to conduct user sessions) with the how knowledge (*e.g.*, supporting reflective practice for designers) [80].

5.2 Implications for Pedagogy & Design

Training Reflexive Design Students. In the past, HCI designers have focused more on functionality and usability of technologies. Today with the third wave of HCI, the field is exploring more ethical and critical questions about doing design [1, 2]. This investigation has led us to ask, what is at risk if we do *not* train reflexive human beings through our classroom practices? We propose that HCI is not just about understanding how to engage the end user, but about the human who is leading the engagement with the end user to design something for other users.

We have found that the process of noticing can prompt critical thinking about design situations that seem ephemeral in the moment; where the process of noticing is no longer just noticing flaws or design changes that need to be made in the interactive technology but about noticing opportunities for improvement of our interactions through design processes. We offer three ways that educators can scaffold noticing for their students in their classroom: through the use of multi-faceted reflection prompts, curated video clips, and ongoing reflection prompts. Informed by HCI literature

on reflection in HCI [13, 51, 57], we augmented the original course structure and provided multifaceted reflection prompts, curated video clips, and ongoing reflection activities. Moreover, beyond showing what aspects of how scaffolded noticing worked and did not work in our findings, we highlight what is possible when educators take the time to encourage noticing in the classroom. We encouraged students to go deeper into their engagements with end users to strengthen their ability to notice in the moment. By teaching them where to look, as design educators, we were supporting students in developing their own instincts of what is a key moment in an interaction during a user session.

Designing Pedagogy to Support Students to Curate and Interpret their Video. To support reflective practice and noticing, skilled educators, facilitators, and students can collaborate to curate and interpret video. For educators who may not have the time and resources to curate video clips for students, we propose a spectrum of solutions: On the lighter end, educators can send out the full video clips and have teams watch and annotate them. Students can also record moments using their smartphones, use those clips as sources of inquiry and reflection, and have conversations with the teaching team for feedback. On the higher effort end, educators can watch the recording and pull out “teachable moments” for teams to watch, as we did in our work. Students could also support each other in interpreting their clips during designated course time—a strategy that enables peer learning. Peer feedback requires rapport, trust, and respect such that peers can direct and receive critiques in a positive manner.

Additionally, HCI educators can pause, reflect, and notice moments within their teaching. Educators (experienced and new) could review clips from their courses and share successes and opportunities in group settings. Given the recent shift to remote learning due to COVID-19, reviewing clips recorded from Zoom or online lectures can more easily become a common practice. In a virtual setting, educators can record themselves, curate clips of their teaching engagements, and then use those clips for viewing and discussion with another instructor. This might also be an opportunity for cross-discipline collaboration between educators (*e.g.*, computer science, interaction design, art) who all teach project-based learning and share strategies. In our future iterations of the course, we plan on leveraging the opportunity of recording sessions on Zoom and immediately sending them to the students to review between sessions.

Designing Technologies to Curate Video. For HCI educational technologists, we also see an opportunity to innovate on the tools and techniques that can be used to scale video-based reflections. In professional sports, technology and coaching staffs have grown significantly to do rapid review of game play, clip key moments, and facilitate video sessions even during the game itself (*e.g.*, at half time) [86, 87]. In HCI education contexts where there are limited time and resources, we envision tools that can quickly curate moments or distribute the process of curating clips among students. Toward this vision, a teaching center created an initial tool that records classroom interactions in 2-minute segments for review [21]. Video annotation tools also support students in quickly tagging, clipping, and describing their interactions [49]. Future work that seeks to design technologies to support HCI pedagogy and reflective practices can involve a range of HCI educators

and students to consider the ethical implications of recording and reviewing video.

5.3 Limitations & Future Work

Effort to Curate and Distribute Video Clips. There was considerable effort from the team to curate and distribute the video clips to students which including properly consenting every student to be recorded during their PD sessions. During the course, six researchers looked through video recordings to identify two clips that could be sent to each student team (24 clips total), annotated the key moments, and named whether it was a successful interaction or a challenging interaction. We understand that not every educator might have access to the resources our researcher team had. We see an opportunity for future work to design tools that can support the curation of clips for reflection. Due to the COVID-19 pandemic many interactions now take place in the online space which provides more opportunities to easily record user studies for review and reflection at a later time.

Context. The students in this study come from a highly selective master's program with a strong cohort-based culture. This influences the ways in which they reflected with each other and reviewed their video clips together. Future work might explore how to ensure reflection in groups is done in a psychologically safe space.

COVID-19. Our university implemented stay-at-home measures for COVID-19 during the last portion of the course, preventing students from completing the last of their testing and iterations on projects. We conducted interviews virtually at the height of the pandemic in March 2020. This limited the experiences we heard from students after we shared a link to their video clip given their health and safety concerns on the state of the world.

6 CONCLUSION

There is increased momentum in HCI education to actively investigate, reflect on, and propose implications for pedagogical approaches [63, 81, 82]. In this paper, we presented a Research through Design investigation [80] of a studio-based HCI course, which was revised based on HCI education research recommendations [13, 51, 57]. We described how students experienced key changes from Year 1 to Year 2 of our course: introductory PD lecture, PD templates, pre-PD session reflections, post-PD session debriefs, and mid-quarter reflections. Our findings suggested that our course revisions helped scaffold students into a complex user-study context, consider best- and worst-case session scenarios, and collectively identify opportunities for future action for their second user-study sessions. We presented the pedagogical characteristics that supported and hindered students' reflective practices from our revisions, including multi-faceted reflection prompts, curated video clips, ongoing engagements as well as uncomfortableness of watching oneself, activity timing, and the lack of buy-in. And we offered insights that students gained as part of our reflective exercises: attending to moments of inclusion and exclusion, attending to body language, navigating engagements with users, and naming future actions. Our work highlighted how students can practice reflection and noticing during sessions with users similar to the ways in which teachers, athletes, and healthcare workers review their

practice using video. This paper translated insights from existing literature noticing and reflection in pedagogy to the context of HCI where designers must attend to moment-to-moment interactions with users throughout the human centered design process. Future work might explore the sustainability of the strategies for reflection we found, investigate the long-term impact of design students' experiences working with end-users, and embrace reflective practices for HCI pedagogy.

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