Opportunities and Challenges in Involving Users in Project-Based HCI Education

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ABSTRACT
Users are fundamental to HCI. However, little is known about how HCI education introduces students to working with users, particularly those different from themselves. To better understand design students' engagement, reactions, and reflections with users, we investigate a case study of a graduate-level 10-week prototyping studio course that partnered with a children's co-design team. HCI students participated in two co-design sessions with children to design a STEM learning experience for youth. We conducted participant observations, interviews with 14 students, and analyzed final artifacts. Our findings demonstrate the communication challenges and strategies students experienced, how students observed issues of power dynamics, and students' perceived value in engaging with users. We contribute empirical evidence of how HCI students directly interact with target users, principles for reflective HCI pedagogy, and highlight the need for more intentional investigation into HCI educational practice.

Author Keywords
HCI education; User-centered design; Reflection

CSS Concepts
• Human-centered computing-Human computer interaction (HCI)

INTRODUCTION
Involving users throughout the design process is a key tenet of HCI research and practice [78, 105]—even the terms "*user*-experience" (UX) and "*user*-centered design" reflect this focus. Consequently, HCI pedagogy emphasizes the need for students to be exposed to and directly work with users in authentic design settings [23, 24, 58, 78]. Surprisingly, little research has been conducted on how HCI students interact with users, particularly those different from themselves. While rich literature exists on user-centered design and evaluation methods such as participatory design (PD) [9, 42, 62, 63, 65, 68, 72, 98], design probes [53, 55], and online technologies [4, 56], prior work has not explored how to operationalize these findings into educational practice within the constraints of an academic HCI course.

CHI '20, April 25–30, 2020, Honolulu, HI, USA.
 ACM 978-1-4503-6708-0/20/04. $15.00
DOI: https://doi.org/10.1145/3313831.3376530

Recently, HCI educators have begun to reflect more on pedagogy and practice [105]. One way for students to practice their design skills is through studio-based learning approaches [29, 45, 58, 83, 93, 101]. Existing HCI courses often ask students to find and work with users to ideate, test, and iterate on their design projects [77]. From our own experiences as HCI educators and prior work [52], we know that students often select users with convenience sampling [73] (*e.g.,* their roommates, peers, neighbors, and friends from social media). This is a challenge for HCI education because students need to learn how to work with a wide range of users [24]. But how do (and should) HCI educators prepare students for this task? And what challenges do HCI students encounter in their design process?

To better understand how HCI students engaged with, reacted to, and reflected on working with users in their design process, we integrated a children's co-design team with a master's student (MS) HCI prototyping studio course. We refer to "co-design" as the involvement of end-users as part of the PD process [33, 34]. In the 10-week course, graduate students worked in teams to iteratively design and build a low-cost physical computing "STEM learning" experience and an accompanying lesson plan for 3rd-6th graders. Each design team participated in two co-design sessions with children using *Cooperative Inquiry*, a PD method focused on children as design partners with adults [33]. Our core contribution is not to study how to incorporate co-design methods into the classroom but rather to document and offer guidelines about how to incorporate users from different backgrounds into our HCI teaching practices.

In our research, we were specifically interested in two key questions: ***RQ1.*** How do HCI students engage with users unlike themselves during their design process? and ***RQ2.*** What value do HCI students perceive in working with users different from themselves in their design and reflection process? To address these questions, we drew upon three sources of data: video recordings from eight 90-minute co-design sessions, semi-structured interviews with a subset of HCI students after the course ended (n = 14), and artifacts from final project documentation. For the interviews, we asked questions about how students prepared for and

experienced the co-design sessions, challenges and concerns, and advice for future HCI students. We also showed video clips of their co-design sessions and asked students to talk about and to reflect on their interactions with the children. Following the interviews, we collected and analyzed final project artifacts from seven participating students. We triangulated across our data to analyze the co-design sessions, collect personal accounts from the students, and to better understand how design decisions were influenced by the co-design sessions.

Our findings reveal how design students *communicated* with their users and challenges therein, the complex role of *power dynamics* between designer, user, HCI student, and other course stakeholders (*e.g.,* the educator), and how the students *perceived* value in working with users through reflection. Our work shows the need for more intentional focus and investigation on HCI pedagogy, such as how HCI students build rapport with their users or how they navigate complex power dynamics when engaging with users and facilitators. Overall, we make three contributions to the HCI community:

1. Empirically, we uncover the nuances and complexities of HCI students engaging users unlike themselves in their design process, thereby uncovering the design complexity [96] between designers and users.
2. Theoretically, we extend Sengers *et al.*'s [84] notion of reflective practices in HCI pedagogy and education.
3. We provide recommendations for reflective practices on student engagement with users in HCI education.

RELATED WORK

"This is the core of interaction design: Put the user first, keep the user in the center, and remember the user at the end."

-Alan Dix *et al*., *Human-Computer Interaction*, 2003 [31]

Users in HCI Practice

As eloquently captured by Alan Dix, users are fundamental to HCI—both in research and in practice. Below, we provide an overview of how industry and academia involve users in design demonstrating: (a) how HCI distinguishes between methods for involving users, (b) how design models espouse multiple touchpoints with users, and (c) a spectrum of methods and considerations for involving users.

HCI practice often distinguishes user-oriented methods by considering design stage [12, 31, 46, 60, 64, 78]. At each stage, a spectrum of methods exists, leaving a multitude of choices for HCI students to think about, assess, and draw upon in their design processes. For example, the *Nielsen Norman Group* illustration shows 20 popular research methods for user experience ranging from behavioral to attitudinal (*x*-axis), and qualitative (direct) to quantitative (indirect) (*y*-axis) [104]. Other methods might be modified for engagement with a specific population, such as older adults [62, 65]. HCI textbooks also distinguish methods depending on user context [78]. Controlled settings, such as laboratories, allow for precise experimentation with users, but limit the naturalness of the interaction. In contrast, field studies allow for observation of users in the real world but require additional resources and time [78].

Similarly, there exists a wide range of well-established HCI design models to describe the process of design [6, 25, 35, 91]. These models (*e.g.,* STAR [48], d.school [75], IDEO [54], interaction design [78]) often focus on multiple touchpoints with users in particular stages of design (early, middle, later stages) [31]. Notably, in many of the well-established design models we reviewed [31, 35, 78], it is not explicitly clear where engagement with users fits in. HCI educators may adapt these models and highlight user engagement for their classroom context, but this is not well documented in the literature.

In the formative stage process [31], designers are encouraged to understand users' needs, goals, and context. Methods such as formative interviews, surveys, and focus groups might be used. In the middle stages of design, with the focus on developing early prototypes, methods such as Wizard-of-Oz, mock-up critiques, and design probes are helpful to evaluate a range of ideas. In the summative design stage [31], where designers are evaluating functional prototypes [91], there are many different methods for user evaluation: empirical or experimental, observational methods such as think-alouds [5, 71], query techniques [31], user-feedback interviews [106], questionnaires [59], and physiological monitoring methods (*e.g.,* eye-tracking) [41, 76]. Methods such as participatory design [16, 33, 82, 95] support engagement with users throughout design stages [19, 22, 69, 78].

While user involvement is seen as critical throughout the design process, there are many contributing factors including time, access to users, and resources if designers want to work with users in-person [44]. With limited constraints, HCI practice also utilizes useful techniques for iterating on designs without involving users directly, such as heuristic and model-based evaluations [87, 88]. However, they are not a replacement for usability testing with the people for whom the system is intended, the users [31].

Despite the long history and extensive literature on involving users in HCI practice, there has been surprisingly little scholarship on how to integrate users in HCI education and pedagogy. Based on this review, open inquiries remain about how HCI educators expose students to these techniques and opportunities. While we have models [13, 35], frameworks [80], and methods [1, 103, 111] for working with users, there is considerably less knowledge about how HCI students actually engage with users and how to consider this interaction as part of HCI education and pedagogy.

Bringing Users to HCI Education and Pedagogy

Within HCI education and pedagogy, involving users into students' design projects is common across design contexts [81], however there is a lack of depth in understanding the interactions between designers and users.

In Agogino *et al.'s* [2] research, students worked in-person with target users and industry sponsors during an interactive

concept generation workshop. Students reflected on the value of working with users. However, the authors provide little detail on how students worked with the users, how the students prepared for their workshop, and how they perceived their interactions with users in the moment or after.

Silveira *et al.* [90] documented a course project in which students interviewed a group of five children to develop a health game. HCI educators stressed the importance of children being involved in the design process so that the students could understand the children's point of view for this project. However, the study offered few details about *how* the students worked with the children. In their discussion section, the authors note, "*contact with people outside the class, whether being project stakeholders and/or potential end users is always a challenge*".

These challenges have led educators to innovate on how they can work with target users within educational contexts. Hui *et al.* [52] explored the use of a crowd-based platform to help design students engage with users online instead of in-person. They created activity-based interventions to help students collect and analyze data from online crowds. These activities informed their design decisions and helped overcome challenges of connecting students with users in-person [52]. One benefit of this approach was that students were able to collect large sampling of user sentiments in a short amount of time [52] However, HCI researchers highlight that these online activities for user-research methods are supplemental to current design methods, not replacements [4, 52].

Despite strong proponents of providing students with an authentic experience of working with users, design educators identify challenges which limit student interactions with people outside of the classroom [52]. Students may face anxiety when contacting people that they do not have a prior relationship with [52]. Establishing connections between students and potential users also takes time and energy for both the educator and the student [52]. From the user perspective, it is important to consider the potential burden it places on users to be engaged throughout the design process [4, 10, 52]. Finally, student designers may lack etiquette [52], which could influence future partnerships between students, course instructors, and users.

To understand the challenges and benefits HCI students experience working with users, our study documents close engagements of users and designers in a classroom context through PD methods. Literature that closely examines these engagements between designer and users unlike themselves in class-base settings is sparse. Through our exploration, we provide new knowledge and implications for how to engage HCI students in working and learning with child users, who are different developmentally than adult designers.

METHODS

For this investigation, we adhered to the standards and practices of a case study methodology [66]. The bounds of this case are between January to March 2019 for a 10-week graduate-level design studio course, which used *Cooperative Inquiry* with an intergenerational design team of adults and children (ages 7–11) to co-design STEM learning experiences with Arduino. We consider this investigation as a *revelatory case* [109], which Yin describes as examining an understudied phenomenon previously inaccessible to social science inquiry. By closely analyzing how HCI graduate students–ranging from no experience to some youth experience–work together with children, we shed light on the challenges and strategies HCI students face when engaging users that are unlike themselves.

MS HCI Course Context

The context of this work is a one-year, cohort-based, HCI and design master's program at a large research university. In this program, students take a range of HCI and Interaction Design courses including user research, data visualization, physical prototyping, and interactive system design. During the 10-week course, 34 HCI students worked in teams of three or four with an external corporate client to ideate, design, and implement a low-cost STEM learning prototype with Arduino for middle school children. The learning activities were aimed at addressing one or more *Next Generation Science Standards* [70]. The high-level course learning goals were: (1) to engage in the full human-centered design process—from ideation to lo-fidelity prototyping to building and evaluating an interactive prototype; (2) to develop, learn, and use a range of prototyping techniques; and (3) to develop and learn techniques to solicit, analyze, and incorporate feedback from a range of stakeholders.

Teams were provided with examples, such as a *seismograph* built from coiled wire and a microcontroller to measure induced current from seismic movement [100] and an *anemometer* made from paper cups, a straw, magnets, a reed switch, and a microcontroller to measure windspeed [3]. To help scaffold and structure their design process, teams were given assignments that followed a standard user-centered, iterative design process beginning with ideation and low-fidelity sketching, then storyboarding, video prototypes, and Wizard-Of-Oz prototypes, followed by three 'check-in' milestones related to their final functional prototypes.

Each team conducted two co-design sessions with children, solicited feedback from in-service teachers, and received design critiques from peers, teaching staff, and the corporate client. Final deliverables included an interactive hardware prototype, a video, and a lesson plan, which were showcased at an event hosted by the client. HCI student teams engaged in two co-design sessions with children: one in early stages (Weeks 3 and 4, Sessions 1 - 4) and one in later stages (Weeks 7 and 8, Sessions 5 - 8). HCI students prepared for the sessions by attending a lecture on PD methods by the lead facilitator of the intergenerational design team that included videos of prior co-design sessions, research context of the co-design team, and an overview of design partnerships [110].

Name	Gender	Sessions	Project	Background, design experience	Prior experience with children
Sophie	Woman	3&8	Green house	Informatics, Educational tools	Indirect, Worked with teachers on curriculum
Biya	Woman	3&8	Green house	Engineering, Autonomous vehicles	Limited, Capstone project with children
Toby	Man	2&8	Electro Crane	Data analytics, Freelance design	Limited, Volunteered in high school (HS)
Dale	Woman	4&7	Pinball	CS, Product design (7+ years)	Indirect, Worked with mothers
Trista	Woman	4&6	Echolocation	Graphic design, Visual design	Limited, Volunteered in church
Tim	Man	3&8	Car ramp	Software development, Project manager	Limited, Volunteered in HS
Nina	Woman	3&7	Robo-bat	Art history, Art and museum education	Experienced, Worked as camp counselor
Jake	Man	1&6	Trebuchet	Chemical engineering, Product designer	Limited, Volunteered at science center
Sadie	Woman	1&7	Soccer	Industrial design, Graphic design	Experienced, Two projects with children
Tess	Woman	4&5	Magnetism	Education, Educator (10+ years)	Experienced, Worked with children across ages
Josh	Man	3&7	Robo-bat	Finance, User researcher (3+ years)	Zero to none
Stephan	Man	1&6	Trebuchet	Architecture, Freelance visual design	Limited, Project with children in college
Abigail	Woman	3&8	Car ramp	Psychology, Worked at IRB and lab	Experienced, Worked informally with children
Yue	Woman	4&7	Pinball	CS, Interface design	Limited, Taught a music class while in HS

Table 1. Characteristics of master's student participants. All names are pseudonyms.

Participatory Design Sessions with Children

For the co-design sessions, the HCI students utilized a specific PD methodology called *Cooperative Inquiry* [34, 110], which emphasizes close design partnerships between children and adults. Cooperative Inquiry was appropriate for our context because the method bridges power dynamics between designers and users through partnerships. Given the task of designing a STEM learning tool for middle school children, Cooperative Inquiry facilitated close interactions for adult designers to work with children, rather than merely having children test a system or provide quick feedback [34, 72, 110]. In this way, the co-design sessions allowed for HCI students to engage with users that were different than themselves during their design process.

All co-design sessions included designers and users; three to four MS student teams, five to seven children (ages 7-11) from an intergenerational co-design team, called *KidsTeam UW*, undergraduate volunteers and a lead facilitator. All of the children had one to four years of prior experience with KidsTeam UW and had established rapport with the co-design team members (children, lead facilitator, volunteers); however, the MS students and KidsTeam UW members did not know each other prior to the course. As part of a larger research study, parental and child assent was obtained and approved by our university's Institutional Review Board for ethics. We also obtained consent from the HCI students themselves to be video recorded during the co-design sessions and audio recorded during interviews.

Each KidsTeam UW co-design session started with 15-minutes of *snack-time* for the HCI students and volunteers to build relationships with the children. After *snack-time*, HCI students, children, and volunteers came together for 15-minutes of *circle-time* where they shared their name, age, and the question of the day to help everyone get ready for the design activity. During *design-time* (45-minutes), each HCI student design team had a station set-up and the children rotated in pairs to each station for 10-mins each. To close, during *discussion-time* (15-minutes) the facilitator led a discussion with all four teams and the children to share likes-dislikes [102] for each prototype presented. Sessions were distributed over two weeks and scheduled based on design team preferences and children's availability; therefore, the teams had different prototype maturities at each set of sessions. For each session, the HCI student design teams had autonomy in planning their design time with children, but the course instructors gave them high-level structure and potential questions to explore.

Video Data and Clips Selection

We collected and analyzed video data from all eight co-design sessions. Two researchers watched and time-stamped video data from the co-design session to identify notable moments of interaction between HCI students and children. For the 14 HCI students who agreed to be interviewed, we selected 3–5 different two-minute video clips to help them *notice* [86] what was happening in their interactions. Our selection criteria for the clips focused on showing a moment when: (1) the student was notably engaged with a child (*e.g.* child appeared to be distracted, student appeared to be frustrated, a challenging moment, or student and child seemed to be communicating well) and (2) two or more researchers decided there were multiple interpretations to the interaction. Prior to the interview, two researchers reviewed the list of potential video clips, discussed which clip might generate more discussion from the HCI student, and selected one clip per HCI student.

Interviews and Artifacts

After the course ended, we recruited 14 out of 34 enrolled students to participate in a semi-structured interview via two email requests. At least one student from each team agreed to participate (Table 1). Participants received a $25 gift card for their time. Interviews were in two parts: in part one, we asked questions about participating in the co-design sessions, challenges and concerns, and advice for future HCI students. In part two, we conducted a video probe to prompt discussion on their interactions with the children [86]. Our interviews were audio-recorded and lasted between 45-60 mins. The first author was present at all 14 interviews, often with a second researcher, and wrote reflective memos after each interview. We audio recorded and professionally transcribed the interviews. After the interviews, we followed up with a request for artifacts from the participating students. We collected and analyzed documentation for six (of ten) final projects (Figure 1) to see how the students incorporated feedback from the co-design sessions they attended.

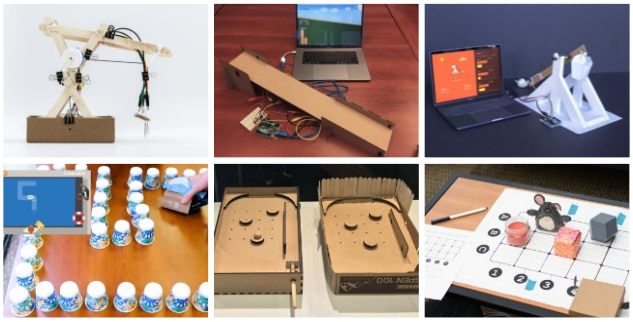

Figure 1. Final prototypes (L-R, Top: Electro Crane, Car Ramp, Trebuchet, Bottom: Echolocation, Pinball, Robo-bat)

Data Analysis

To analyze our qualitative data (video, interview, artifacts), researchers began with an inductive process through open coding with constant comparative analysis [67]. Five researchers open-coded the data from the first five interviews independently for 9 codes such as power, discipline, and communication. We compared themes to further develop 34 sub codes for analysis informed by HCI education literature, our video annotations, and memos from the interviews. Once an initial codebook was developed, two researchers independently coded the data and used peer debriefing as a validation check for each transcript [28]. Next, we grouped and iterated on the codes according to consistent themes which then led to additional codes such as expectations, prior experiences, and perceived values from the experience. We further iterated on our codebook (provided in our supplementary materials) by triangulating [27] across the three sources of data we collected. We used axial coding to make connections across codes for our results as a team and performed a constant sorting and comparative analysis until theoretical saturation was reached and no new themes emerged. The authors of this paper then iteratively discussed themes across the three sources of data and abstracted three higher-level themes and common patterns. We engaged in peer scrutiny across authors who were familiar with the co-design sessions, interviews, users, HCI students, and class, to ensure the trustworthiness of our interpretations [85].

Positionality Statement

Qualitative research is personal—the positionality of the researcher plays a role in the research process, in the field, analysis, and text [26]. As a research team, different components of this study were influenced by our subjectivity and thus require reflexivity [38]. Some are educators that have spent years iterating on our pedagogy. Others have spent years working with KidsTeam UW. Finally, we are committed to the development of future HCI scholarship that centers those at the margins at the core of our research. These lenses informed our analytical approach.

FINDINGS

We report on three primary themes: how design students *communicated* with their users and challenges therein, the complex role of *power dynamics* not just between designer and user but also design student and educator, and how the HCI students *perceived* value in working with users. Below, we use the terms 'HCI student' and 'designer' interchangeably as well as 'child' and 'user.'

Communicating with Users

Building Rapport with Users to Elicit Feedback

Building rapport between designers and users [61] is a critical component of participatory design [19, 34, 37]. The Cooperative Inquiry [33] method, in particular, allocates the first 15 minutes of a design session for establishing rapport: an informal "snack time" for designers and users to eat and talk together and a "circle time" share, which serves both as a formal introduction and ice breaker. Despite this structure, we observed that a majority of HCI students did not focus on rapport building, especially in their first set of sessions. For example, during "snack time," the HCI students self-segregated and communicated amongst themselves, rather than talking with the children (Figure 2). In "circle time," some HCI students felt uncomfortable revealing information about themselves to the group, which was intended to strengthen connections. For example, Dale said, *"I didn't like talking about my age because I'm 37. I'm there with 19-year-olds, but it was cool. Everyone talked about their age."*

Figure 2. Children and students during snack time (Session 3).

Some students reported feeling more confident in their second sessions, drawing on their experiences from the first session. For example, when testing a prototyping of a game, one child chose to be team members with a designer instead of with another child based on their previous interactions. However, for some designers, the disconnect remained in both the first and second set of sessions. Nina recognized the time limitations of only having two opportunities to build rapport with the children, *"Like we had two individual sessions. It's really hard to build rapport with them."*

Despite time constraints—which typically exist in HCI practice as well—some students successfully implemented strategies to connect with users and gather rich insights, including adopting welcoming body language and expressions (*e.g.,* smiles), adapting their language to be more child-like, using friendly gestures, and dynamically changing co-design activities to pique curiosity. For example, during co-design Session 8, after a child successfully put together a complex Arduino breadboard, an HCI student high-fived the child as a compliment. To facilitate ease, designers acted silly, such as asking children to pretend to be scientists. During Session 1, an HCI student cleverly prompted a user's curiosity by saying, *"what if I told you this thing goes somewhere else as well?"*, which transformed the co-design

experience into a game. Reflecting on these strategies, Toby said: *"I think that it has to be dynamic in a way where sometimes you have to act like a kid. Sometimes you have to act like an adult to make sure that you get what you want out of the session.*" Finally, successful teams demonstrated empathy when children struggled with their prototypes. For example, in Session 3, one of the designers (Josh) also shared their frustration with non-working prototypes. In this case, the child expressed motivation to keep going.

Session Management Challenges and Strategies

Managing user study sessions is a multi-step process that begins before the session itself, including study protocol preparation and deciding on data collection metrics [21]. While the HCI literature describes and modularizes the tasks involved in planning and running user study sessions, they do not often focus on the 'live dynamics' of a session and how to manage unexpected events [31, 60, 78, 103]. We found that HCI students struggled to dynamically change their study protocol in response to children's reactions/behaviors, were not comfortable with their leadership role, were unaware of strategies to bring sessions back on track, and struggled to transition between user tasks. Josh described, *"We were a lot firmer when it came to the agenda. You have to do the activity, the sketching, the digital interface. Some children didn't comply. They just ran away. The others were fine, but the reaction was mixed."*

When children started using prototypes, they often did so in unexpected ways. For example, children attempted to eat the chia seeds initially brought for an experiment (Session 3) and repeatedly threw large objects using an early-stage trebuchet prototype (Figure 3, co-design Session 1). HCI students had difficulty responding and adapting to this unexpected behavior, which sometimes led to frustration, demoralization, and a feeling of lack of control. Stephan, a member of the Trebuchet team, said: *"As designers it really challenged our concept of affordances… they would make use of anything that they would see in the way they wanted to… they used the trebuchet to throw projectiles at the windmill… that was not what we were expecting."*

Figure 3. Children exploring uses of the trebuchet (Session 1).

In response to children's unexpected interactions, HCI students wanted to control and direct the children's behavior. Yue explained, *"Especially like that little girl, she just could not stop playing with the pinball machine. Even after the volunteers said to discuss… this girl was still playing with the pinball machine. We couldn't stop her."* When lack of control occurred, some of the designers would react by repeating instructions and/or eventually giving up. While disruptive to the designers' plans, these children *were* providing valuable feedback (whether recognized or not). In Yue's case, the child was absorbed by playing with their pinball prototype—demonstrating engagement and providing ample opportunity for observational analysis (Figure 4). Often, however, the HCI students were focused on how they personally believed children should interact based on their protocol.

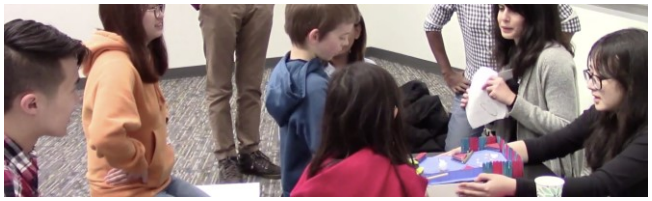

Figure 4. Children playing with pinball machine (Session 4).

When children provided complex forms of feedback, designers had difficulty processing and reacting in-the-moment. Toby expressed this challenge, *"you have to try to learn how to read between the lines and try to understand… they say this thing, but what does it mean? What is behind that?"* Similarly, Abigail commented, *"So, like once we got that far, and again because we didn't have a structured plan of what our questions would be, we were like, what does that mean? How do we make sense of this information? So, we just kind of resigned to like, we're not making sense of this information. We're just getting general things out of this…"* In both cases, users gave designers unexpected and abstract feedback that they struggled to process.

We also observed a number of successful session management strategies, including one-on-one interactions, being clear and explicit with directions, and moving between methods quickly (*e.g.,* sketching, questioning, testing, ideating). During Session 3, for example, an HCI student team moved between asking questions, using design probes, and prompting sketching methods as they tried to understand their user's knowledge of a science concept. Designers quickly adapted their interactions with the children, instead of staying on a strict agenda. The designers observed the time limitations and attention spans of the children and changed their methods appropriately.

However, complex dynamics between designers and users also took the form of managing different user personalities. Designers were not sure how to pay attention to quieter users. Dale explained, children would not always verbally respond to design questions: *"I think he felt a bit overwhelmed by our questions…We would ask him questions, and he would be like, 'I don't know' for everything."* The designers also did not know how to divert attention from dominant user personalities. For example, Stephan said *"So, what happened was a handful of them, like I think two or three of them were sort of the dominant kids, and the rest of them we'd have to like talk to them and like get to know them. We then had their participation. That was tricky to do, but we went through it."* Designers responded to dominant personalities either through

one-on-one attention, patiently asking the other users what they thought, or attempting to ignore the dominant personality. Some designers implemented changes to their prototype that took into account how dominant personalities might use it. Overall, Nina noted how this user engagement between quiet and dominant personalities informed how they designed their game to, *"make space for children who have different personalities."*

Complex Role of Power Dynamics

Navigating power dynamics between designers and users is a well-known problem in HCI with issues related to social desirability bias, soliciting honest feedback, and overly eager acquiescence [97]. These dynamics are further exacerbated with child users because they are a vulnerable population at risk to the influence and power of designers [18]. Although PD methods have attempted to disrupt this power imbalance by actively engaging users in the design process [15, 34], we highlight two situations where HCI students held more power (with users) and when power came into conflict (with other adults). Surprisingly, despite identifying and recognizing power dynamic issues, HCI students did not feel equipped to address them. Disrupting acts of power takes intentional reflection, awareness, and confrontation strategies [7, 30, 51].

Power Dynamics Between Designers and Users

Designers drew on their own lives and prior experiences when preparing for the co-design sessions with children. For example, Abigail said, *"I come from a traditional southern (U.S.) background… this notion of quick reactions or raising your voice, things like that, that feels very intuitive to me, and I actively try to fight that…That's how I was raised, so it's like I feel like my interactions sometimes are tainted by that."* Similarly, Biya said, *"In China we have this really strict culture where you need to respect the elders, the teachers, especially when you're at a young age. The teacher has higher authority, and I know that's so different from the western world. I find that to be fascinating."* Abigail and Biya's statements illustrate how designers recognized the ways in which their prior experiences influenced how they engaged with users in the design process, and how they wrestled with this tension. Many designers we interviewed stated, in one form or another, that they had expectations of the children based on their own lived experience.

Similarly, designers' interactions with the children demonstrate some of the complex power dynamics when engaging with multiple users. Designers identified not knowing how to pay attention to multiple users at once (despite the fact that there were more researchers than users). In co-design Session 3, Biya and Sophie (the greenhouse effect team), gave one child a bag of seeds with Alka-Seltzer and another child with a bag of seeds that did not have a catalyst for growth (Figure 5). The user with the latter bag asked "*Okay, what do I do?"* to which the designers responded, *"Yours is the one with carbon dioxide, you have to wait until it grows."* The user disappointedly waved his bag around and said, "*oh no!*" In this case, power over users occurs as the group made a decision that appeared to be not equal to a child user. Biya's team expected children to be able to wait patiently (a perfectly reasonable request), but they did not recognize that by giving one child the bag with the more curious seeds, the session created a less than exciting experience for the other child holding a bag of seeds.

Figure 5. Children comparing bags of seeds (Session 3).

Finally, the HCI students talked about the ways in which children's input was positioned relative to other adult stakeholder influences. Toby highlighted, *"Sometimes I think that even though the kids are really excited about something, but then I have to think about the feasibility of it too. Like they're interested but is it educational for them?*" With Toby and other designers, we observed that despite the setup of the co-design sessions as a part of the course, other stakeholder input from teachers and the client played a larger role in informing their final designs. Overall, across these examples, designers recognized the ways in which power dynamics between them and other adults (*e.g.,* volunteers, clients) influenced their design process and specifically how it de-centered the needs of the users in the final design.

Power Dynamics Between HCI Students and Other Adults

In interviews, HCI students described the challenge of managing expectations when working with users, the influence of their peers and faculty input, and user input across other adult stakeholders (*i.e.,* industry partners). The design partnership between the graduate HCI program and team allowed for interaction between designers and children. But, because children are a vulnerable population, volunteer facilitators were present to manage and guide ethical and safe engagements between the children and the HCI students.

However, because of this facilitation, HCI students expressed their perceptions of who was in charge of the co-sessions and how they felt they were not in a place to question the structure of the activities. For example, Sophie said, "*Speaking of power dynamics, you know, we had a professor [lead facilitator of KidsTeam UW] come in and give us a talk about this being his research project, so I'm going to defer to what he wants me to do."* Sophie described the feeling of lack of power that many designers experienced where they did not have agency over how they engaged with users, which in turn influenced the amount and quality of user input they received. She told us that if given the chance she would run things differently by eliminating the drawing markers from the beginning and enforcing her role as the designer. She said, "*I felt like I'm the adult in the situation. Like it should be a regular experiment…"* referring to how she would want to run the structure of KidsTeam UW. At the

same time, designers often acknowledged the need for ethical and transparent oversight into working with children but wished for more agency in the activities of the sessions.

Other HCI students described how they relinquished power over their engagement with the users to teammates who had more experience working with children. During co-design Session 4, we observed how Yue let her teammates take over leading the debrief conversation with users. She expressed in the interview she did not feel as comfortable with the children. This meant Yue may not have gotten the full experience of engaging users in the design process.

Perceived Values through Reflection

HCI students working with children in user-centered design is an opportunity to deeply understand the values and tensions in HCI education, particularly as designers differ greatly in cognitive and social development from children. In our interviews, we gave HCI students an opportunity to reflect on their work with children. Reflective practices [17, 49, 83, 84] allow for deeper meaning making in engagements we may take for granted in HCI education. In this section, we highlight the reflective practices of these designers' engagements with users beyond technical skills and assessment. In each of these examples, student reflections show an introspective view of themselves as designers beyond grades, achievements, and skill set development.

Navigating Complexity with Users Through Adaptation

Designers reflected on the complex nature of working with users. Typically, HCI textbooks offer advice on working with users, such as the need to adapt to contexts [60] and positive case study examples of successful implementation of user interactions [78]. However, when going through real-life interactions with users, the designers went more in-depth with their advice than found in the literature. Abigail said that interactions with challenging users showed her, as opposed to told her, *"KidsTeam UW informed my education because it showed me the value of being flexible… I need to work on my feet and be adaptable…develop more flexible study guides or like learning how to extrapolate data I didn't intend to receive. Those are all valuable things. They're just not traditional academic definitions of education. It was more experiential…"* In this quote, Abigail questioned traditional assumptions of classroom learning, compared to real engagements with users. Abigail's flexibility is shown in designers' recognition of the need to accommodate multiple user needs for feedback during sessions.

Other designers provided actionable reflections and strategies to respond to the complex user interactions. Trista advised, *"(To) bring something that's more interactive so you can get the kids' attention and also you get to play with them more instead of just passively watching or listening to things."* Additionally, Nina stated, *"I think I had not realized it as much until we talked about it, but I think that like moving away from questions to more like freeform design"* such as drawing with the children. Sadie realized that even if you bring in arts and crafts for feedback, children have different abilities when it comes to using those materials. Overall, HCI students recognized the challenge and proposed solutions that came from interacting with users unlike themselves.

Awareness of Further Opportunities for Growth

Another important value we highlight is HCI students' reflections of growth opportunities for professional development and user engagement. We argue that these are positive instances of their learning, as HCI students reflected on both doubt and development. For example, Trista noted, *"So, now looking back, I mean I still don't know what's the best way to communicate with her (child). I would have wished we could have done that better. To get her engaged… It was really hard to balance because we have such little time."* Sadie described her desire for additional information about users, *"So, I feel the standard and age group is something we didn't really know. We certainly can search the information online, right."* Tim articulated his need to continue further learning, "*It's like I don't even know if I did that the right way. If I could… just step back and watch an expert do it for like an hour, then I would probably have a better grasp of maybe what it should look like and maybe work myself toward that image of what co-design is*." These quotes highlight how co-design can, with reflection, help professional development and growth.

Designers Remembering and Noticing

Finally, we note the importance of the difference between how designers remember their engagement compared to what happened. Human memory can be unreliable [99]. In our case, we found that the HCI students often remembered their co-design sessions with children differently than the recorded videos would suggest. During reflection in the interviews, HCI students were surprised, shocked, and nervous when they watched their own interactions on video. When watching his own interaction from Session 3, Tim noted, *"This is interesting because my perception of what happened on this day is now completely different from what I see. Yeah, this seems like it was very structured like we were getting something out of it, but like what I remember from this day was not…"* This quote is important for educators to recognize how designers might be overly critical of their own previous actions and those of the user.

DISCUSSION

Previous literature in HCI education makes recommendations about working with users in many different ways, including guidelines for involving users [12, 46, 60, 64], methods and techniques for engaging with users [1, 103, 111], and models and stages for different processes in user interactions [6, 31, 35, 48, 54, 75, 78, 91]. While user engagement is at the core of HCI, literature on HCI education and pedagogy for student practice focused on working with users is sparse. The empirical contributions of our case study uncover the nuances and complexities between HCI students and users. By identifying the communication strategies and challenges, power dynamics, and reflections, we show the need for more intentional focus and investigation on the aspects of HCI education that remain invisible. We see opportunity for

future HCI education research that provides students with real-world experiences with users unlike themselves and draws on reflective HCI as an important pedagogical practice for these experiences.

Design Complexity Between Students and Users

Current literature on HCI education notes that students often rely on convenience samples (*e.g.,* friends, roommates, neighbors, and similar status persons) for user feedback [52]. This is unsurprising, given the difficulties in finding, supporting, and helping HCI students work with users that differ from their own worlds.

We recognize that not all HCI educators will have a partner like KidsTeam UW. We highlight the value of investing into community partnerships for HCI courses to connect students with a broad range of users. Existing HCI course examples include Dr. Forlizzi who encourages students to partner with multiple stakeholders in their Service Design course [40] and Dr. Snyder (Jaime Snyder, personal communication, 2019) who partners with a group that advocates for LGBTQ+ homeless youth in their design methods course.

At the same time, researchers advocate for HCI education that faces these complexities head on. Stolterman [96] argues for a "design complexity" approach—that is, that design practice must be grounded in its true nature of messy reality. Design practice must be based on deep understanding of the nature of human action. In our findings, we observed this design complexity between the designers and users. Designers face an overwhelming number of decisions and judgments they must make about specific people (who themselves are incredibly complex with their needs, desires, and situations) [96]. While HCI education might try to reduce design complexity—through guidelines, methods, and prescriptions for HCI students on how to work with users—it is difficult to replace the benefits of experiential learning. We observed this as HCI students wanted clear guidelines on how to work with children and expressed a desire to manage the children to act in certain ways they thought appropriate.

Instead, Stolterman argues that complexity is not a necessary evil, but if given the right circumstances and support, HCI students who experience this complexity can create truly positive experiences filled with challenges [96]. Further, Stolterman describes design practice as the creation of a desired reality manifested into an "ultimate particular", for a specific user, with specific functions, and done within a limited time and resources [96]. We claim that HCI education needs to consider how to support challenges HCI students experience when it comes to frustrations and interactions with users. Kou and Gray [57] highlight the need for innovative pedagogical methods that support the education of better designers towards knowledge acquisition and competence development. They note that preparation for students involves having designer interactions in a more natural setting, particularly as students face a dynamically changing profession. Our case study findings suggest that by having HCI students work with children as users in a safe, but complex space, they were able to go deep into reflections on how to best strategize and work with users that were different than themselves with respect to ethnic and social identities. HCI educators can support HCI students through this complexity by anticipating the challenges we uncovered and developing pedagogical ways to prepare designers (*e.g.,* via role-playing or reading case studies) before heading to real-world settings.

Power and Ethics Between HCI Students and Users

We also need to acknowledge the issues of power dynamics between the designers and the users of this study. Our findings note that power dynamics are a core theme and tension between designers, stakeholders, facilitators, and users. There will always be tension between what a designer envisions, what a user wants, and what a user can provide in an ultimate particular [96]. In our investigation, HCI students expressed some difficulties with having a facilitator mediate between the designers and the children. In the context of co-designing with children, adults are often involved to make sure children are safe (*e.g.,* teachers, parents). Similarly, in the context of working with an elderly population or those with chronic illness, their caretakers are responsible for managing how the interactions take place between designers and users [62, 63, 65]. HCI students need to learn how to navigate the dynamics between what they want to do and the limits of what a user can provide. We build on Dombrowski *et al.*'s commitment to polyvocality in design by highlighting the need for future work that closely investigates designer-user interactions in HCI education [32].

Understanding power dynamics leads us to a discussion about ethical considerations of designers and users in pedagogical practice. In our specific situation, children are a vulnerable population [18, 47]. We must critically think about the effect this pedagogical experience has on the users. For example, although all children and parents consented to be a part of this work, we need to think about the burden users might face in such design sessions (*e.g.,* disagreements, boredom, arguments). As designers face design complexity, we acknowledge this tension of educating HCI students on working with users with different identities, but we must also consider difficulties among working with users in pedagogical practice, such as those with accessibility needs [8, 14], chronic health challenges [11], homeless participants [107], senior citizens [65], and other marginalized populations that could differ from designers. As we strive to include a wide range of users in our design process and train future HCI practitioners with a wide user base, we have to ask ourselves how we might achieve these goals without placing unacceptable burden on the users.

Reflective HCI as Important Pedagogical Practice

Finally, in this investigation, we found our interview methods of HCI students watching their clips as an important pedagogical tool that can be used more frequently in HCI. In our findings, as designers took time to review their previous study sessions and reflect on their engagements with users,

they were able to go more in-depth about the complex nature of interactions with users. Reflection brings unconscious aspects of activity and experiences to conscious awareness, making them available for conscious choice [84]. Reflective design is a practice that has been advocated in HCI [74, 84]. Sengers *et al.* [84] approach design through existing critical approaches in computing and argue that "*reflection itself should be a core technology design outcome for HCI*." As such, reflection as a form of stepping out, thinking about, and connecting forward, [79] provides an opportunity for HCI educators and students to spend time making sense of designers' experiences in project-based courses, particularly when working with users unlike themselves.

Currently, HCI education literature focuses on providing designers the tools, methods, guidelines, and framework for working with users [31, 60, 78, 103], but not yet the reflexive practices needed to critically assess engagement with users. Such reflective practices are more common in teacher education, where teachers must often consider the complex nature of their engagement in the classroom [43, 49, 94]. We support building into HCI education ways to consider the importance of reflection as HCI students interact closely with users. To this degree, we extend Sengers *et al.*'s notion towards reflective practices in HCI pedagogy and education. From our findings, we adapt principles of reflective design pedagogy as designers engage with users [84]:

- HCI pedagogy can leverage reflection to uncover complexities, tensions, and dilemmas of user engagement in HCI education.
- HCI pedagogy can use reflection to re-understand designers' role in the process of working with users.
- HCI pedagogy can support educators and students to reflect on their lives as they interact with users.
- HCI pedagogy can support skepticism and propose recommendations as designers engage with users.
- Reflection is not a separate activity after designers engage with users, it is folded into HCI curriculum.
- Dialogical engagement between users, designers, and educators through technology can support remembering and enhancing reflection.

Implications for HCI Students and Educators

Our findings suggest two recommendations for HCI education towards student engagement with users. First, we suggest creating a repository of case studies to reflect on difficult interactions between designers with users. Churchill *et al.* [24] acknowledges the need for a repository of educational materials in HCI but expresses the need for a group of dedicated individuals to champion the creation of this repository. We advocate for case studies of HCI student engagement with users, which are often a very important pedagogical tool [36] for medicine [50], education [89], law [20], and other fields [108]. This work has started in HCI for ethical practices with users [39, 92]. We recommend HCI educators compile case studies to help designers challenge, reflect, and think about multifaceted interactions with users.

Second, we recommend using Van Es and Sherin's [86] methods of reflection with video viewing. In their research, they developed a "video club" where pre-service teachers brought in monthly video clips of their pedagogical practice to reflect on together with other teacher candidates. Similarly, in our interviews, HCI students had the chance to think and reflect together on engagement practices with users. In future work, HCI students can self-record and self-select their own video clips for reflection. We believe there is potential in this video club strategy for HCI education, as designers reflect on user engagements.

Limitations & Future Work

Several limitations exist in our investigation. Design students engaged in co-design with a group of children from a predominantly higher-income background. The children in KidsTeam UW have been doing co-design with partners across the university for many years. The context of this investigation was in a highly selective master's program at a large research university. Overall, while our findings focus on a specific group of master's students and group of children with which they engaged in the co-design process, we believe learning how to work with users, particularly those who have different experiences, within real-world constraints is an important lesson for all designers.

CONCLUSION AND FUTURE WORK

HCI education programs across the world have grown dramatically, moving from single fields (*e.g.,* computer science) toward multidisciplinary and transdisciplinary spaces. While HCI education has paid much attention to user-centric engagement, primarily in the form of methods or strategies, there is great need for HCI students to engage and develop knowledge of working with users (in the form of soft skills and experiential knowledge) that comes about in actual design practice in complex situations. Students not understanding or appreciating the importance of these skillsets early in their development can create situations where they face conflict or become unreflective designers. This investigation and its rich descriptions of HCI students' engagement with users unlike themselves points to the need for future work to investigate other designer-user situations to help our community recognize the design complexities that exist in such interactions. Overall, we believe there is great potential in the creation of reflective pedagogical practices to develop HCI students that enter the world, not shying away from messy reality, but facing it head on with the right skills and attitudes.

ACKNOWLEDGEMENTS

We thank the children, master's students, faculty, volunteers, and CHI reviewers for their contributions to this study. This study was supported by a National Science Foundation Graduate Research Fellowship Program (NSF GRFP).

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